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When More is Less: Understanding How to Leverage Expertise Diversity Manifested in an Electronic Advice Network

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When More is Less: Understanding How to Leverage Expertise Diversity Manifested in an Electronic Advice Network

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

August 2011

Acknowledgements

I am so grateful for the following people, without whom I could not have completed this dissertation. First, I sincerely thank my dissertation committee for their assistance and guidance. I acknowledge the inspiration, advice, and guidance of my advisor, Sirkka Jarvenpaa throughout my doctoral program. Her everlasting passion for research and teaching and her outstanding work ethics have helped to grow as a mature researcher and teacher. I also appreciate Cynthia Beath, Reuben McDaniel, Hüseyin Tanriverdi, and Kyle Lewis for their constructive suggestions. I offer a special thanks to Cynthia Beath for offering me positive, supportive, and thorough feedback when I needed it and encouraging me to work to my full potential. I also want to thank my colleagues and fellow PhD students who also offered feedback and encouragement. I acknowledge that this dissertation could have not been done without the full research support of Dan Ranta of my field research site and the employees in my sample who participated in this study.

I am so much indebted to my family. I thank my wife, Dasan Kim, for her endless patience, tireless support, love, and sacrifice. Without her, I would not have survived this dissertation journey. My boy, Christopher Hayule, was a wonderful oasis for me when I needed a break from the hard work of writing a dissertation. I love him so much. Last and not the least, I would like to thank my parents, Kwangsoo Kim and Seunja Hwang, and my parents-in-law, Kiljoong Kim and Yunhee Kang, for their empathy, patience, sacrifice, prayer, financial support, and love. I also thank my sister, Suna, and in-laws, Dongki, Jisan, Jiwon, and Hosung, for their emotional support. I thank God for all of you.

When More is Less: Understanding How to Leverage Expertise Diversity Manifested in an Electronic Advice Network

Publication No._____________

Yongsuk Kim, Ph.D.
The University of Texas at Austin, 2011

Supervisor: Sirkka L. Jarvenpaa

An electronic advice network provides employees opportunities to tap diverse experts within the organization at an unprecedented speed and scale. It is formed when an advice seeker initiates an online discussion thread joined by members of various communities, each specializing in a specific domain. This dissertation recognizes the substantial gap in our understanding of how to best harness the performance potential of expertise diversity provided through an electronic advice network within a firm. It thus investigates the process by and conditions under which expertise diversity in an electronic advice network promotes the advice seeker's learning and performance. A field study was conducted via multi-methods including observation, interviews, and survey at a global company running discussion forums spanning internal virtual communities. The unit of analysis was at the discussion thread level. 190 discussion threads comprising

1,200 participants and associated outcomes (rated by their respective advice seekers) were analyzed. Findings suggest that, for the seeker to realize the performance potential of diverse inputs, discussion participants should facilitate the seeker's learning by engaging in collective elaboration—articulating the differences and relevance of their diverse inputs. The seeker learned and performed the least when discussion participants were highly diverse but did not engage in collective elaboration. Discussion participants engaged in collective elaboration to the extent that they had previously established shared syntactic and semantic understanding of each other's expertise domains through participation in each other's communities. This dissertation contributes to the virtual communities literature by unearthing the relationships between expertise diversity and the advice seeker's learning and performance and explaining when and how the seeker benefits from the diverse knowledge shared through an electronic advice network. The moderating role of collective elaboration explains why prior research may have found no or even a negative relationship between expertise diversity and discussion outcomes. It also contributes to the team literature by offering boundary conditions for the previous findings on expertise diversity and common ground. The collective elaboration construct can be also adopted by team diversity researchers to better understand where a disruption in the chain of group-level information processing may occur in some diverse teams.

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CHAPTER 1: OVERVIEW

INTRODUCTION

In recent years virtual communities of practice have emerged as a new IT-enabled organizational form. Since opportunities for face-to-face interactions among employees are limited in today's globally distributed organizations, virtual communities of practice are becoming an alternative platform for interactive knowledge sharing (Ardichvili et al. 2003; Teigland and Wasko 2003; Wasko and Faraj 2000; 2005; Sproull and Arriaga 2007; Kudaravalli and Faraj 2008; Jung and Boland 2009; Moon and Sproull 2009). In this dissertation, virtual communities of practice refer to firm-hosted, technology-mediated virtual spaces supporting knowledge sharing among large, geographically distributed, voluntary groups of employees through technological features such as discussion forums and knowledge repositories. These are organization-bounded virtual communities organized primarily around specific expertise domains and practices, open to all interested employees (Teigland and Wasko 2003; Ardichvili et al. 2003). The motivating premise that justifies firms' heavy investment in virtual communities of practice is that their employees can seek advice for their problems by tapping a pool of experts with experience and insight distributed across the company at unprecedented scale and speed (Ardichvili et al. 2003).

As knowledge work becomes ever more complex, non-routine, and multidisciplinary, many teams (including project teams and functional groups) in the organization find the success of their work hinges more on the exposure to diverse perspectives and approaches and on the integration of different pieces of knowledge provided from different domains of expertise (Hansen 1999; Gray and Meister 2004; Mengis 2007; Ratcheva 2009). Members of a community can be diverse in many respects (e.g. work location, organizational level (position)) but still relatively homogeneous compared to those in other communities in terms of main expertise domain. Thus, teams struggling with a complex problem may need to tap not just one but multiple virtual communities of practice to seek and integrate different pieces of knowledge to arrive at a solution for their problem.

In order to facilitate advice seeking and advice providing for multidisciplinary problem solving, firms such as IBM, Samsung, and ConocoPhillips provide IT-enabled platforms on which employees can seek, access, and share knowledge across communities. For instance, online discussion forum can be used to form an instant "electronic advice network" by providing bridging links among a network of virtual communities whose specializations are related to the problem under discussion (Novak and Wurst 2005; Novak 2007; Ziovas and Grigoriadou 2008). An electronic advice network is formed when an advice seeker initiates a cross-network discussion thread that spans multiple virtual communities and members of different communities participate in the discussion thread to share their domain-specific knowledge. Within a few clicks, members of different communities can easily join any discussion thread of their interest and start providing their inputs to the team problem described by the advice seeker (advice seeker refers to an individual who poses a question on a discussion forum to seek technical advice for problem solving or better decision making related to a problem his or her team has encountered).

The strength of an electronic advice network is believed to lie in its far-reaching access to a wide range of diverse knowledge, perspectives, and approaches. It is believed that the advice seeker (and his/her team) would greatly benefit from the exposure to the diverse expertise of electronic weak ties. However, there is little discussion in the virtual communities literature about the interaction between members of different communities and the difficulties of sharing knowledge across boundaries. Researchers who examine virtual communities tend to limit their analyses to the practices of single communities rather than investigate what happens when members of different communities need to communicate their domain-specific knowledge. Furthermore, most research on knowledge sharing in electronic advice networks, whether single community-focused or not, remains at the individual-level of analysis, mainly focusing on why people share their knowledge; the underlying assumption is that once the management understands this and adequately motivates individuals to make their expertise or themselves available for leverage, advice seekers would benefit from accessing diverse expertise.

While the performance potential of leveraging expertise diversity, or expertise domain differences represented by advice providers in a discussion thread, is advocated by the information processing perspective in the team diversity literature, there has been a lack of theoretical and empirical interests in the virtual communities literature as to whether (and how likely) this view holds true in the context of electronic advice networks (i.e., online discussion threads joined by advice providers from different domains). Although several studies have surveyed or qualitatively rated the informational benefits of advice providers' knowledge, the analysis was typically done at the individual message-level. Consequently, these studies were unable to capture the process and the outcomes of collective discussion on the seeker's inquiry, not to mention their relations to the advice providers' expertise diversity (e.g., Wasko and Faraj, 2005; Zhang and Watts, 2008).

Only a few studies have touched upon the assumed positive relationship between expertise diversity and the advice seeker's learning and performance, but they did not find supportive empirical evidence (Constant et al., 1996; Kudaravalli and Faraj 2008). For instance, Constant et al (1996) found from a field study of an email listserv that the diversity of advice providers (with respect to organizational positions) did not predict the advice provider's problem solving success/performance. They even found a negative relationship between diversity and the perceived usefulness of the overall advice. These findings call into the question the dominant view that the advice seeker will benefit from an electronic advice network that provides diverse, non-redundant informational inputs. Furthermore, review of the team diversity literature reveals that an expectation of positive effects of expertise diversity on group outcomes are justified based on assumptions specific to traditional teams, but some of the assumptions do not hold in electronic advice networks, raising a further question about the validity of the dominant view in the virtual communities literature.

RESEARCH QUESTION

Taken together, there is a gap in our academic understanding of the process through and the conditions under which the expertise diversity manifested in an electronic advice network will lead (or fail to lead) to effective knowledge sharing outcomes such as learning and performance. Therefore, this dissertation explores the following research question:

> *How and under what conditions does expertise diversity in an electronic advice network promote the advice seeker's (team) learning and performance?*

In this dissertation, the unit of analysis is at the discussion thread level. Each discussion thread has one advice seeker and multiple advice providers. I will later introduce two more constructs—collective elaboration and cross-network common experience—, and both of the constructs and the expertise diversity construct are measured at the discussion thread level. The outcomes of a discussion thread are reflected in the advice seeker's team learning and performance. As previously defined, the advice seeker poses an inquiry on behalf of his or her team. I assume that the discussion content is shared by the seeker's team and the seeker's individual learning and his or her team learning are nearly the same. I will elaborate more on this assumption in the section on assumptions and boundary conditions.

RESEARCH APPROACH

Theoretical Approach

In order to answer the research question, it is important to better understand the knowledge sharing process of an electronic advice network. Recently, several IS researchers have began exploring the nature of interactions that unfold in online discussion to better understand what makes advice seeking in online discussion more effective. For instance, Kudaravalli and Faraj (2008) explored how dense discussion was initiated and sustained by discussion participants, which was, in turn, positively related to idea generation and problem solving. Similarly, Jung and Boland (2009)'s case study of online discussion forums highlighted the role of conversation practices in group learning. Advancing this line of research further, this dissertation addresses the proposed research question by focusing on how discussion participants share their domain-specific knowledge in their communicative interactions and when they are able to do so.

Adapting the relational properties of knowledge at a boundary from Carlile (2004), I consider how the difference, relevance, and novelty of domain-specific knowledge held by discussion participants create both opportunities and challenges to the communication and understanding of discussion participants' knowledge. I first consider how discussion participants explicate the relevance of their domain-specific knowledge that differs in degree and/or in kind through "collective elaboration." Collective elaboration refers to a knowledge sharing process through which discussion participants articulate their knowledge and viewpoints not just in depth but also, more importantly, in relation to others.' Building on the literature on elaboration, I propose that collective elaboration moderates the effects of expertise diversity on the advice seeker's learning and, subsequently, on performance outcomes.

On the other hand, the novelty of domain-specific knowledge provided by discussion participants can create communication boundaries that may impede collective elaboration if discussion participants do not have shared syntactic and semantic understanding to begin with. Building on the literature on knowledge boundaries and communities of practice, I consider the condition under which discussion participants are likely to have shared syntactic and semantic understanding of each other's expertise domains. "Cross-network Common experience" refers to the extent to which discussion participants have previously developed semantic and syntactic understanding of the expertise domains represented by other participants in a given discussion through regular participation in all their respective virtual communities. I propose that discussion participants' cross-network common experience moderates the effects of expertise diversity on collective elaboration.

Empirical and Methodological Approach

I collected both primary and secondary data from a global energy company well known for its successful running of internal virtual communities to facilitate knowledge sharing among employees. I first conducted field observation (i.e., monitoring of discussion threads involving members of single or multiple virtual communities) and pre-survey interviews with 16 employees identified as highly active advice seekers and/or providers. The main purpose was twofold: to informally assess the likelihood of the relationships presented in my research model; and to develop the basis for constructing the coding scheme for *collective elaboration* and for revising my survey questionnaire. Because there was no established measure of collective elaboration, I developed a coding scheme based on related construct measures, discussion thread data, and the feedbacks from the interviewees.

I collected primary data via a survey of advice seekers whose discussion threads had met the eligibility criteria of this dissertation. The primary data mainly concerns *the advice seeker's team learning* and *performance outcomes* resulting from the particular discussion triggered by the seeker's inquiry. I received 190 complete survey responses (tied to190 unique discussion threads comprising 1,200 participants). I collected secondary data related to the 190 surveyed discussion threads and their discussion participants to measure *expertise diversity* and *cross-network common experience*; I also conducted a content analysis of the 190 discussion thread contents to measure *collective elaboration* —all three at the discussion thread-level.

Because I had multi-item constructs in my model, I examined the discriminant and convergent validities and internal consistency reliability of the constructs. In addition, I assessed the inter-rater reliability of the *collective elaboration* measures (I worked with another coder to code the 190 discussion thread contents based on a coding scheme of *collective elaboration*).

To test the hypothesized relationships presented in my research model, I conducted two analyses. First, I conducted hierarchical (sequential) regression analysis. The assumptions of regression were all met. Hierarchical regression analysis was chosen because my main interest lay in testing the significance of interactions. Moderation effects were further tested via simple slope tests. I tested the mediation effect of learning via Barron and Kenny and Sobel tests. To check the robustness of the findings, I additionally ran partial least squares (PLS) regression analysis and found the same results.

Assumptions and Boundary Conditions

Like all research, this dissertation rests on certain assumptions and has boundary conditions. First, the virtual communities of interest in this dissertation are firm-hosted communities that are specialized in specific technical domains and run strictly for business objectives under management sponsorship. This dissertation assumes that every discussion participant has what he or she considers to be a “home” community, whose specialization most closely matches his or her main expertise domain, and that he or she participates most actively in his or her “home” community even if he or she is a member of multiple virtual communities. This is an important assumption to make because one’s main, or “home,” expertise domain will be empirically determined by the community in which one participates most actively. My preliminary interviews confirmed the validity of this assumption.

Second, while there is a range of technology that enables electronic advice networks within the organization, this dissertation exclusively focuses on online discussion forums that are hosted in virtual communities, but whose threads can be selectively shared across communities via “cross-posting,” when desired.

Third, this dissertation assumes that discussion participants are non-anonymous and thus serious about how their knowledge seeking and sharing are perceived by others in the organization. Consequently, it assumes that the advice seeker does not have to weed out a lot of low quality messages—unlike in public anonymous discussion forums where the advice seeker often expects to receive substantial information noise (Antweiler and Frank, 2004). My preliminary interviews confirmed that people are very cautious about what they provide on discussion boards at the research site because they know that providing misinformation could harm their reputations in the organization.

Fourth, this dissertation assumes that the advice seeker poses an inquiry to seek technical advice for problem solving or better decision making related to his/her team’s task. The advice seeker seeks knowledge that his or her team is jointly responsible for. It is the seeker who poses a question on behalf of his/her team, but it is the team that processes and integrates the collective information fed from the discussion thread. I consider advice seeker as an informant of his/her team and assume no discrepancy between the seeker’s view and the team’s view with respect to learning and performance outcomes. Therefore, advice seekers were surveyed to rate their respective team learning and performance resulted from the particular discussion on their own inquires. Even if the advice seeker was trying to inform him/herself about something he or she was fully responsible for within the team, it can be said that team learning is enhanced by individual learning. In support of this assumption, the majority of the inquires initiating the 190 surveyed discussion threads conveyed first-person plurals such as "we" and "our" and references to sites, projects, and organizational units. In my interviews, I learned that when team units have questions or problems about something for which they are responsible, tapping electronic advice networks ("why don't we (you) ask the network?") is a norm at the research site. The discussion thread triggered by a member of a team is monitored by other team members and the replies provided in the discussion are typically shared and/or discussed in a team meeting.

Finally, this dissertation does not consider discussion threads that are based on simple or single domain specific inquiries. By limiting its focus to discussion threads in which the advice seeker may potentially benefit from advice providers with diverse expertise, this dissertation can shed light on how and when the advice seeker *fails to* realize the performance potential of expertise diversity.

SUMMARY OF CONTRIBUTIONS

Broadly speaking, the findings of this dissertation suggest that in order for the advice seeker to realize the performance potential of the diversity of knowledge shared through an electronic advice network, discussion participants need to facilitate the advice seeker's learning by engaging in collective elaboration. Discussion participants engage in collective elaboration by articulating the differences and relevance of their diverse knowledge contribution. Collective elaboration is possible when discussion participants have cross-network common experience by having regularly participated in each other's virtual communities, thus sharing syntactic and semantic understanding of each other's expertise domains.

This dissertation makes several contributions to the virtual communities research on knowledge sharing by moving the focus toward how to best leverage diverse expertise *once* it is available in an electronic advice network. This dissertation shed light on the process by and the conditions under which expertise diversity promotes or fails to promote the advice seeker's (team) learning and performance. I investigated the relationship by considering how the difference, relevance, and novelty of domain-specific knowledge held by advice providers create both opportunities and challenges to the communication and understanding of discussion participants' knowledge. The findings of this dissertation suggest that the answer to the question of how to realize the potential of expertise diversity is more complicated than has been assumed; without understanding the communicative interactions in an electronic advice network, researchers will not have a clear picture of the relationship between expertise diversity and discussion outcomes. Specifically, this dissertation identified the moderating role of collective elaboration and cross-network common experience as a condition under which discussion participants could engage in collective elaboration. This dissertation also advances our understanding of how the characteristics of an electronic advice network shape knowledge sharing in online discussion groups differently from knowledge sharing in traditional workgroups. This has led to developing virtual community context-specific constructs, collective elaboration and cross-network common experience, and delineating boundary conditions for the findings of the literatures on team diversity and common ground. Finally, the moderating role of collective elaboration also provides implications for the team diversity literature. It offers an alternative explanation for why some prior team diversity research has reported inconsistent findings on the relationship between expertise diversity and team performance and helps to identify where, in its group functioning, a diverse workgroup fails to realize its performance potential.

This dissertation also provides practical implications by highlighting the double-edged sword aspect of expertise diversity–that is, that an advice seeker can benefit the most or the least from diverse knowledge and the difference is determined by how the diverse knowledge is communicated and comes to be understood. Discussion should be a "dialogue," not just a compilation of individual ideas. This dissertation discusses how to facilitate collective elaboration through the use of a discussion protocol and by educating the moderating roles of discussion participants including the advice seeker. I also discuss how to identify what group of communities need common ground in the organization and how to develop cross-network common experience between members of the communities.

Outline of the Dissertation

The remainder of this dissertation is organized as follows:

- Chapter 2: I review the virtual communities literature on knowledge sharing and the team diversity literature on expertise diversity to highlight that the previous research in both literatures has not adequately addressed how and when the advice seeker can realize the performance potential of expertise diversity in an electronic network.
- Chapter 3: Drawing on the relevant literature on group-level elaboration, knowledge boundaries, and communities of practice, I present a research model that attempts to unearth the relationships between expertise diversity and the advice seeker's (team) learning and performance outcomes. I present hypotheses to explore 1) how expertise diversity interacts with collective elaboration and affects both the advice seeker's learning and performance outcomes; 2) whether learning mediates the interactive effect of expertise diversity and collective elaboration on performance; and 3) how discussion participants' common experience affects collective elaboration particularly when their expertise diversity is high.
- Chapter 4: I describe my field research site, data collection procedure, construct measures and the validities and reliabilities of the measures, and the analyses by which the hypotheses presented in Chapter 3 were tested.

- Chapter 5: I present the results of my analyses. Analyses were conducted using hierarchical regressions, simple slope tests, and Baron and Kenny's and Sobel tests of mediation. A supplementary PLS analysis was conducted to corroborate the findings.
- Chapter 6: I discuss the results, theoretical and practical implications and limitations of the study, and directions for future research.

CHAPTER 2: LITERATURE REVIEW

In this chapter, I first present the definition and characteristics of an electronic advice network. I then review the relevant virtual communities literature on knowledge sharing and expertise diversity to highlight the gap in our understanding of the process by and conditions under which the advice seeker realizes the performance potential of expertise diversity in an electronic advice network.[1] In order to understand the existing theoretical rationale underlying the positive or negative effects of expertise diversity on group functioning and outcomes, I review the two dominant perspectives in the literature on team diversity: the information processing perspective and the social categorization perspective. I end my literature review with a critique of how the existing perspectives on the effects of expertise diversity fail to explain the aforementioned gap in the virtual communities literature.

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[1] The literature on communities of practice will not be reviewed in this section. Overall, the literature has examined the effects of diversity on knowledge sharing largely from the knowledge boundary perspective. In the context of inter-community knowledge sharing, challenges to knowledge integration arise because members from different communities of practice experience have difficulty of transferring, translating, and transforming their domain-specific knowledge. Because the research model is partially built on the theoretical reasoning grounded in the literature, I will later review some relevant community of practice studies in the next theory and hypotheses section.

ELECTRONIC ADVICE NETWORK

Building upon Faraj et al.'s (2008) notion of the electronic knowledge network, this dissertation defines an electronic advice network as a special case of the electronic knowledge network with specific emphasis on two characteristics. For the electronic advice network, I adopt the general description of electronic knowledge network, which is "a self-organizing, open activity system that focuses on a shared interest or practice and exists primarily though computer-mediated communication." (p. 270). The network is *self-organizing* in that it is joined by individuals who voluntarily choose to participate in discussion because they share interests or practices, irrespective of their expertise domains. Unlike virtual groups focusing on particular group tasks (Jarvenpaa et al., 2004; Hinds and Mortensen 2005), participants in an electronic advice network would have little sense of shared responsibilities to produce integrative outcomes (e.g., for the advice seeker's task). The term *open activity* indicates that discussion participation is open to anyone interested. Because anyone can enter and leave a thread at any time, discussion participation is so fluid that it can be difficult for the participants to sustain rich and extended dialogue.

As for the electronic advice network, I use the term *advice* instead of *knowledge* to focus my theorizing specifically on the exchange of technical advice rather than in the exchange of just any type of knowledge. According to the Merriam-Webster Dictionary, advice is a special type of knowledge defined as a "recommendation regarding a decision or course of conduct." Accordingly, an electronic advice network provides the advice seeker the opportunity to tap thousands of other employees to seek advice for problem solving or better decision making. A knowledge exchange that merely involves transfer of factual data or reference information is not the main characteristic of the electronic advice network this dissertation studies. The term *network* is used to emphasize the involvement of members from a network of virtual communities in the exchange of advice rather than to emphasize the network structure aspect of knowledge exchange as in Faraj et al. (2008).

There is a range of supporting technology available for knowledge exchange including email (Finholt and Sproull, 1990; Wu et al., 2004), listserv (Constant et al, 1996), Usenet newsgroups (Butler, 2001; Jones et al., 2004), and organizational discussion forums (Teigland and Wasko, 2003; Wasko and Faraj, 2005). This dissertation focuses on online discussion forums that are hosted in virtual communities, but whose threads can be selectively shared across communities via "cross-posting" when desired. An electronic advice network is formed when an advice seeker initiates a cross-network discussion thread that spans multiple virtual communities and members of different communities participate in the discussion thread to share their domain-specific knowledge. Therefore, an electronic advice network is discussion thread-specific, and the term is used interchangeably with discussion thread in this dissertation.

RESEARCH ON KNOWLEDGE SHARING IN AN ELECTRONIC ADVICE NETWORK

Research on knowledge sharing in the virtual communities literature has largely focused on why individuals engage in knowledge sharing. Empirical studies have identified various factors that seem to facilitate individuals' knowledge sharing. Broadly speaking, the factors are related to motivation, personal characteristics, community-related characteristics, and attributes of the enabling technology. Overall, while the dominant research focus on why people share knowledge provides important implications for designing incentives and tools to promote and support sharing of diverse knowledge, relatively little research has been done to understand whether, how, and when the diverse knowledge shared in an electronic advice network benefits (or fails to benefit) the advice seeker.

Research on the Facilitators of Knowledge Sharing

Personal Motivations to Share Knowledge

Virtual communities research has found numerous intrinsic and extrinsic motivational factors that contribute to knowledge sharing. As for intrinsic rewards, individuals who enjoy helping others (altruism) and have high knowledge self-efficacy are found to engage in knowledge sharing more actively (Wasko and Faraj, 2000; 2005; Lee et al., 2006). Reported extrinsic rewards for knowledge sharing range from informational benefits (i.e., learning, access to valuable information or high quality information) (Wasko and Faraj, 2000; Yoo et al., 2002;Wiertz and de Ruyter, 2007), reputational benefits (i.e., name recognition and status) (Wasko and Faraj, 2005;

Jeppesen and Frederikson, 2006) to other valuable outcomes (i.e., monetary rewards, access to valuable resources, fulfillment of personal outcome expectations, and community-related outcome expectations) (Lee et al., 2003; Wasko and Faraj, 2000; 2005; Chiu et al. 2006; Hsu et al., 2007).

While both intrinsic and extrinsic rewards are considered important motivational facilitators of knowledge sharing, extrinsic rewards are found to hinder or outweigh intrinsic motivations to share knowledge in some cases. In one study, a lack of extrinsic reward was found to be negatively related to knowledge sharing (Lee et al., 2006) whereas, in another study, an introduction of an extrinsic reward system was found to be negatively related to knowledge sharing (Fahey et al., 2007). In the latter case, it was argued that extrinsic rewards could invite opportunistic behaviors and conflicts and might hurt social interaction in communities. Even among extrinsic rewards, reputation building might be more motivating for some individuals than tangible rewards (Jeppesen and Frederiksen, 2006). It is thus not clear what rewards are appropriate for knowledge sharing and how they should be linked to quality of knowledge sharing.

Personal Characteristics Related to Knowledge Sharing

In addition to personal motivations, personal characteristics of active participants have been studied in relation to knowledge sharing. Personality characteristics such as an active and helping personality (Wang and Fesenmaier, 2003) and tolerance of failure (Wiertz and de Ruyter, 2007) and personal cognitive attributes such as subject matter expertise and experience (Wasko and Faraj 2005) affect knowledge sharing in electronic knowledge (advice) networks. Personal views of the nature of knowledge also matter. Knowledge is more shared when individuals consider knowledge as a public good (Wasko and Faraj 2005) and this assumption is culturally determined to some extent (Ardichville et al., 2006). Technical affinity (e.g., comfort with computer mediated communications) (Ardichville et al., 2003) and lead user attributes (Jeppesen and Frederiksen, 2006) are also found to be positively related to knowledge sharing.

Community-related Characteristics Related to Knowledge Sharing

While the knowledge sharing facilitators reviewed so far mainly concern individual-level factors, individuals' decisions to share their knowledge happen in relation to other people, suggesting that knowledge sharing has social and relational components to be considered. Community rules and policies regarding member roles and practices in the virtual community greatly influence members' knowledge sharing (Yoo et al., 2002). Individuals who are centrally embedded in the community, having many social ties, are likely to share knowledge more actively because they ascribe to norms of cooperation (Wasko and Faraj, 2005; Chiu et al., 2006). How individuals feel about their communities plays an important role in their knowledge sharing behaviors. Moral obligations to the community (Wasko and Faraj, 2000) and commitment to the community (Wiertz and de Ruyter, 2007) promote sharing. Individuals' sense of belonging and positive emotional attachment to their virtual communities enhance the willingness to socially engage with others in the community, which in turn lead to better knowledge sharing quality (Chiu et al., 2006). Similarly, a sense of community has been found to enhance knowledge sharing (Yoo et al., 2002; Lee et al., 2006). In addition, when a community holds a strong norm of reciprocity, members are more likely to commit their time and effort to share their knowledge (Wasko and Faraj, 2005; Chiu et al., 2006).

Finally, trust plays an important role in fostering knowledge sharing (Hsu et al., 2007). Knowledge sharing may begin with generalized trust in the community (Ridings et al., 2002), but generalized trust may turn into more interpersonal trust over time as a group of strangers belonging to the same community experience positive knowledge sharing outcomes (Usoro et al., 2007). Various studies have explored knowledge sharing in relation to the emergence of different types of trust, including generalized trust, integrity-based trust, identification-based trust, ability-based trust, and benevolence-based trust (Ridings et al., 2002; Usoro et al., 2007; Hsu et al., 2007).

Attributes of Enabling Technology Affecting Knowledge Sharing

Finally, given the IT-enabled nature of electronic advice network, several technical attributes have been identified as knowledge sharing facilitators. System quality, indicated by system speed, reliability, user-friendliness, functionality and recovery, was found to have a positive indirect effect on participation in knowledge sharing (mediated by sense of community) (Yoo et al., 2002). Lee et al. (2006) approached knowledge sharing in discussion boards from the usability perspective and found that individuals did not share their knowledge if they had poor usability experiences in terms of social interaction, information design, navigation or access.

Similarly, Wang and Fesenmaier (2003) found that ease of communication was a facilitator of knowledge sharing in an online (travel) community.

The review of the virtual communities literature on knowledge sharing reveals three limitations, as follows. First, most research remains at the individual-level of analysis, dominantly focusing on why people share their knowledge; second, some studies looked at the quality of knowledge provided by advice providers, but the analysis was typically done at the individual message-level, unable to capture the process and the outcomes of collective discussion on the seeker's inquiry (e.g., Wasko and Faraj, 2005; Zhang and Watts, 2008); and third, there has been little interest in investigating what happens when members of different communities share their domain-specific knowledge.

Research on Expertise Diversity in an Electronic Advice Network and Knowledge Sharing Outcomes

Understanding why individuals do or do not share knowledge is important because firms can better design incentive structures, tools, and processes that help access and leverage the collective intelligence of "electronic weak ties" (Constant et al., 1996) available within the firm. The implicit but prevalent assumption in the virtual communities literature is that the more individuals are willing to share their knowledge, the more diverse pool of expertise the advice seeker is likely to tap, and the more likely the advice seeker will find non-redundant, useful information and even innovative solutions to the problems at hand (Constant et al. 1996; Cummings 2004, Cross and Cummings 2004; Huang and DeSanctis 2005; Wasko and Faraj 2005). The strength of an electronic advice network is believed to lie in its ability to span "structural holes" (Burt

1995), brokering knowledge flows between diverse, previously unrelated or weakly connected ties from different communities by involving them in joint online discussions (Constant et al. 1996; Ardichvili et al. 2003; Teigland and Wasko 2003; Huang and DeSanctis 2005).

Therefore, previous research sees the unprecedented opportunity to tap into and benefit from a broad pool of globally distributed individuals with diverse expertise as the most important reason why many business organizations are keen to foster electronic advice networks and the like (Ardichvili et al. 2003). Expertise diversity, a characteristic of an electronic advice network, refers to the expertise domain differences represented by the discussion participants in a discussion thread. Adopted from Van der Vegt and Bunderson (2005), it refers to the extent to which discussion participants differ from each other in specializations, or the knowledge and skill domains in which they are specialized, as a result of their work roles and experience. Discussion participants refer to the advice seeker who initiates a discussion thread on behalf of his or her team and advice providers who contribute their domain specific knowledge by providing replies to the advice seeker's query.

There has been, however, lack of theoretical and empirical interest in investigating whether and to what extent the advice seeker actually benefits from diverse inputs. Little research has investigated how the process of knowledge sharing is manifested in practice and what is actually being shared (Kosonen 2009). Only a few studies have explored the relationship between expertise diversity and performance, but their findings are mixed, calling into question the assumption that the advice provider will benefit from an electronic advice network as long as diverse, non-redundant informational inputs are provided through the network. For instance, Teigland and Wasko (2003) found from their field survey that employees' reliance on electronic advice networks for advice seeking was related to increases in the levels of individual creativity and performance (they assumed but did not test the positive effects of expertise diversity). Some studies found that neither the sheer number of replies nor the diversity of advice providers necessarily increased the likelihood of obtaining good advice or solving the advice seeker's problem (Constant et al. 1996; Kudaravalli and Faraj 2008). Constant et al. (1996) studied an email listserv used in a company and closely followed who asked what questions and who answered them via email threads and also surveyed advice seekers to have them rate the responses to their questions by usefulness and whether their problem was solved. While they found that the expertise of advice providers was positively related to the usefulness of their advice, they also found that the diversity of advice providers, which reflected differences in expertise and skills, had nothing to do with the seeker's problem solving success. It was even found that the more diverse advice providers were, in respect to their positions in the organization, the less useful was their overall advice. Kudaravalli and Faraj (2008) conducted a content analysis of online academic discussion threads and found some relationships between expertise diversity and idea generation but no relationship between expertise diversity and problem solving. Problem solving success was measured on the basis of the advice seeker's acknowledgement of the overall value of the responses to his or her query. Jung and Boland (2009) reported a case study in which a question poster often failed to learn from an online discussion forum despite the diverse inputs of experts. In my preliminary study of discussion threads joined by members of diverse communities, there were as many advice seekers who reported negative discussion experience as those who reported positive experience. Together, these studies suggest that the relationship between expertise diversity and the advice seeker's performance outcome is not as straightforwardly positive as has been generally assumed in the virtual community literature.

Taken together, there is a gap in our academic understanding as to when and how the advice seeker can harness the performance potential of expertise diversity provided through an electronic advice network within a firm. While individuals' decision to share knowledge requires motivation, certain personal and community characteristics, and an appropriate technical support, knowledge sharing is "a social process involving complex structures, relational processes and cognitive frames" (Kosonen 2009, p.159).

Given that the theoretical support for the positive effects of expertise diversity on the advice seeker's performance is "borrowed" from the team diversity literature, as the first step to fill the gap, I review the team diversity literature to survey the two dominant processes that shape the effects of diversity on group functioning and performance, the information processing perspective and the social categorization perspective, in the next section.

PERSPECTIVES ON THE PERFORMANCE POTENTIAL OF EXPERTISE DIVERSITY OF COLLECTIVES

The effects of expertise diversity on work performance have been largely theorized and explored by team diversity researchers. The positive and negative effects of diversity on group performance are explained by two dominant perspectives in the team diversity literature: the information processing perspective and the social categorization perspective (See Williams and O'Reilly 1998; van Knippenberg and Schippers 2007; Jackson and Joshi, 2010 for review). The information processing perspective (also known as the information/decision-making perspective) focuses on cognitive aspects of group processes, advocating the positive effects of diversity on group performance. In contrast, the social categorization perspective concentrates more on relational aspects of groups, arguing that diversity negatively affects relationships within the group, hurting group performance as a result.

Information Processing Perspective

At the core of the information processing perspective lies the notion that diversity in group composition brings in a broader range of task-relevant knowledge, experience, skills, insights, opinions, and perspectives to the group discussion (Williams and O'Reilly 1998). The exposure to a larger pool of informational resources forces diverse groups to reconcile diverse perspectives for integration, thus triggering cross-fertilization of ideas and more careful consideration of the issues under discussion (van Knippenberg et al, 2004). As a result, diverse groups have a better chance to make a mature decision, solve non-routine, complex problems and produce innovative and creative results. For instance, Jehn and colleagues (1999) found that informational diversity, as measured by differences in education and functional area, led to more task conflicts within the group by exposing differences of opinions and viewpoints over the task itself, but task conflict positively influenced group performance. Similarly, other studies find that diverse workgroups produce more creative and innovative ideas (Ancona and Caldwell 1992; Bell et al. 2011) and problem solving (Ancona and Caldwell 1992; Bantel and Jackson 1989), deal with non-routine tasks more effectively (Jehn et al. 1999), and generate higher performance (Pelled et al. 1997; Hamilton et al. 2003; Cummings 2004) than homogenous groups. Josh and Roh (2009) conducted a meta-analytic review of 8,757 teams in 39 previous studies done in organizational settings and found that task-related diversity was positively related to team performance; specifically, functional diversity, which is close to expertise diversity, had the strongest positive relationship with team performance (.13), followed by tenure diversity (.03), and educational diversity (-.02).

Social Categorization Perspective

Although the performance potential of diversity remains clear, a growing body of evidence suggests that it is often difficult to realize this potential (e.g., van Knippenberg and Schippers 2007; Joshi and Roh 2009; Kearney et al. 2009; Bell et al. 2011). Team diversity researchers who draw from the social categorization and social identity theories argue that diverse groups fail to capitalize on the performance potential of their diversity due to the intergroup biases triggered by social categorization. According the perspective of social categorization, people tend to categorize others into either similar ingroup members or dissimilar outgroup members based on perceived similarities and differences. Perceived similarities and differences are typically determined by “surface-level” attributes related to demographics such as age, race, nationality, and gender (e.g., Jehn et al., 1999, Van der Vegt and Bunderson, 2005), but non-demographic attributes such as organizational unit affiliations can also provide the same distinguishable cues (e.g., Bunderson and Sutcliffe 2002).

Through social categorization, individuals form more favorable attitudes and more trust toward ingroup members, thereby being more willing to cooperate and interact with ingroup than outgroup members (Brewer 1979, Brewer and Brown 1998, Tajfel and Turner 1986). In line with this argument, homogeneous groups are believed to function more smoothly than diverse groups because members are more attracted to each other and experience less conflict, thus sharing and processing knowledge more effectively. In contrast, in diverse groups, diversity invokes social categorization that is more likely to trigger intergroup biases, which, in turn, disrupt group functioning and lead to lower performance as a result (Williams and O’Reilly 1998; Earley and Mosakowski 2000). Consistent with the prediction of the social categorization perspective, some studies have found that diversity triggered relational conflict among team members, which, in turn, was negatively related to team performance (Jehn et al. 1999; Pelled et al. 1999).

In the context of an electronic advice network, the negative effects of diversity triggered by social categorization are rarely expected for the following two reasons: first, for diversity to trigger social categorization, similarities and differences should not only be salient, but the grouping also has to be sensible to the individuals in the group (van Knippenberg and Schippers 2007). Ingroup/outgroup formation is less likely to occur in an electronic advice network because they have little reason to do so—the advice seeker initiates a discussion to deliberately seek different knowledge and perspectives from others and advice providers choose to voluntarily join the discussion with the intent to offer help; second, "deep-level" diversity such as expertise diversity is less likely to trigger adverse social categorization processes than does "surface-level" diversity because it is not immediately salient (Dahlin et al., 2005). Furthermore, surface-level characteristics such as race, gender, and age are much less apparent online (Donath 1999; Sproull and Kiesler, 1986), thus less likely to provide bases for us-versus-them distinctions. Consistent with the idea that computer-mediated interaction removes social categorization cues (Sproull and Kiesler, 1986), Bhappu and colleagues (1997) found that significantly less intergroup biases in gender-diverse groups when communication was computer-mediated rather than face-to-face.

For these reasons, finding no or negative relationships between expertise diversity and the advice seeker's performance outcomes in an electronic advice network should be interpreted as reflecting the consequences of dysfunctional information processing rather than dysfunctional social categorization.

Group Processes That Underlie the Relationship between Expertise Diversity and Performance in Workgroup Settings

Many diversity studies adopting the information processing perspective mainly focus on main effects by testing relationships between dimensions of diversity and outcomes while assuming, rather than assessing, the underlying group processes. Yet some studies have theorized and explicitly examined group processes including team communication (Earley and Mosakowski 2000), team reflexivity (Schippers et al. 2003), task conflict (Jehn et al. 1999; Pelled et al. 1999), team learning behaviors (Van der Vegt and Bunderson 2005), and elaboration of task-relevant information (moderated by team need for cognition) (Kearney et al. 2009) (See Table 1). Team reflexivity refers to the team's careful consideration and discussion of its functioning. Diverse ideas and viewpoints were found to enhance group performance by stimulating team reflexivity (Schippers et al. 2003). Jehn and her colleagues (1999) found that diversity triggered task conflict, or disagreement about task issues, but task conflict was positively related to group performance. Their reasoning was that the differences in opinions, ideas, and perspectives stimulate group level discussion and learning, leading to careful consideration of the team's task. The effect of task conflict on team performance, however, seems equivocal. Van Knippenberg et al. (2004) argue that it is not the presence or absence of task conflict that helps or hinders performance, rather it is the matter of how conflict is managed. They argue that only when task conflict promotes deep-level processing of diverse information and viewpoints, does it lead to performance improvement. Task conflict itself is not necessary to realize the performance potential of expertise diversity nor does it always trigger deeper information processing within the group. On the other hand, team learning behavior, defined as activities by which team members seek to acquire, share, refine, or combine task-relevant knowledge through interactions, was found to be positively related to diversity (Gibson and Vermeulen 2003) and to partially mediate the moderating effect of collective team identification on the relationship between expertise diversity and performance (Van der Vegt and Bunderson, 2005). Educational diversity were found to be positively related to team performance when team need for cognition was high, and the elaboration of task relevant information mediated the moderated effect of need for cognition on the relationship between diversity and team performance (Kearney et al. 2009). In other words, only when having a strong need for cognition, members of diverse teams engaged in careful and extensive processing and integration of their unique knowledge, which led to higher team performance.

Table 1 Select Group Processes Underlying the Relationship between Expertise Diversity and Performance

Group Process	Study	Definition	Operationalization
Team communication	Earley and Mosakowski (2000)	The perceived effectiveness of communication within a team	(1) "The purposes of the meetings we get involved in are clearly communicated" (2) "We really listen to one another and try to understand the feelings and points of view of each other" (3) "Each of us has the freedom to express himself on any issue at any time" (4) "We freely express our feelings and ideas in meetings"

Table 1 (Continued)

Group Process	Study	Definition	Operationalization
Team reflexivity	Schippers et al. (2003)	The team's careful consideration and discussion of its functioning	(1) "We regularly examine whether our objectives are still appropriate" (2) "In this team, the results of actions are evaluated" (3) "The methods used by the team to get the job done are often discussed" (4) "We regularly discuss whether the team is working effectively together"
Task conflict	Jehn et al. (1999)	Disagreement about task issues	(1) "How frequently are there conflicts about ideas in your work unit?" (2) "How often do people in your work unit disagree about opinions?"
Team learning behavior	Gibson and Vermeulen (2003); Van der Vegt and Bunderson (2005)	Activities by which team members seek to acquire, share, refine, or combine task-relevant knowledge through interactions	Members of their team… (1) "criticize each other's work in order to improve performance" (2) "feely challenge the assumptions underlying each other's ideas and perspectives" (3) "engage in evaluating their weak points in attaining effectiveness" (4) "utilize different opinions for the sake of obtaining optimal outcomes"
Elaboration of task-relevant information (triggered by a need for cognition)	Kearney, Gebert, and Voelpel (2009)	The exchange, discussion, and integration of ideas, knowledge, and perspectives that are relevant to a team's tasks	(1) "The members of this team complement each other by openly sharing their knowledge" (2) "The members of this team carefully consider all perspectives in an effort to generate optimal solutions" (3) "The members of this team carefully consider the unique information provided by each individual team member" (4)"As a team, we generate ideas and solutions that are much better than those we could develop as individuals."

In short, studies adopting the information processing view argue that expertise diversity leads to positive group performance because it stimulates an intensive collaborative group process in which everyone in the group collaboratively processes and integrates domain-specific knowledge brought to the discussion. During this process, participants are assumed to identify and collaboratively resolve the differences in perspectives, assumptions, and approaches and to converge on a solution or decision through knowledge integration. Expertise diversity naturally triggers this kind of in-depth information processing and integration process as long as participants are encouraged to share what they uniquely know and avoid groupthink (van Knippenberg and Schippers 2007). Therefore, some researchers focus on the conditions under which individual contribution of unique knowledge and group discussion on unshared knowledge are encouraged or hampered in diverse groups (e.g., Kearney et al, 2009).

In an electronic advice network, it is unrealistic to assume that expertise diversity will trigger these types of mediating group process. The assumed mediating group processes require conditions that are more likely to be present in traditional team settings. Some of the conditions, however, do not hold in the context of electronic advice network. Participants might collaboratively engage in careful identification, reconciliation, and integration of diverse inputs in a traditional team setting where members work on interdependent tasks and have shared accountability for and commitment to the team outcomes. Task and outcome interdependences create pressure for individuals to collaboratively reconcile their different perspectives and integrate their different inputs.

In an electronic advice network, however, advice providers may not feel pressure to synthesize the differences in their advice to reach a consensus, nor have they shared responsibility for the outcomes of the discussion threads in which they participate. Furthermore, the fluidity of discussion participation—attributed to the openness of electronic advice networks and the lack of individual commitment to sustained participation—makes it even more unlikely that advice providers will exhibit the same level of intensive and iterative group-level information processing as would be seen in traditional workgroups. It is unrealistic to expect advice providers to engage in an iterative collaborative problem solving process in a discussion thread until they reach a consensus for the seeker.

In an electronic advice network, it is the advice seeker and his/her team, NOT the advice providers, who are responsible for processing and integrating different pieces of advice and making a final decision on what actions to take. Therefore, the group process that helps realize the potential of expertise diversity in an online discussion would look different from the ones prescribed in the team diversity literature. Nevertheless, what can be taken away from the review of the information processing perspective on workgroup diversity is that effective processing and integration of diverse inputs requires a group process by which the inputs are *skillfully communicated and come to be understood.*

Therefore, in order to better understand the process by and the conditions under which expertise diversity translates into the advice seeker's (team) performance in an electronic advice network, more focus should be given to how discussion participants' domain-specific knowledge is communicated and understood. Several recent studies have investigated the communicative interactions in online discussion to better understand how they are related to the advice seeker's performance outcomes. In their study of academic discussion forums, Kudaravalli and Faraj (2008) found that how discussion participants initiated and sustained dialogue in discussion was positively related to idea generation and problem solving. Jung and Boland's (2009) study of online discussion forums explored conversation practices and their effects on the advice seeker's learning. Advancing this line of research further, this dissertation addresses the gap in our understanding of the relationship between expertise diversity and the advice seeker's performance outcomes by focusing on how discussion participants share their domain-specific knowledge in their communicative interactions and when they are able to do so.

SUMMARY OF THIS CHAPTER

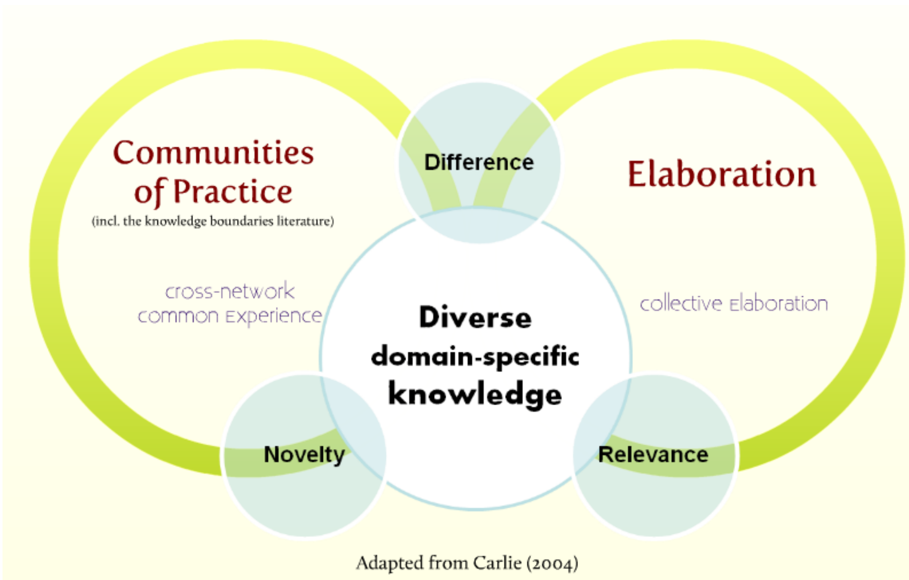
In this chapter, I reviewed the virtual communities literature on knowledge sharing and the team diversity literature to understand what has been theorized and found about the relationships between expertise diversity and group processes and outcomes. My review of the virtual communities literature reveals that significant research has been done to understand why people share their knowledge, but relatively little research has examined how to best harness the diverse knowledge provided through an electronic advice network. The discrepancy between the dominant view that the advice seeker will benefit from a discussion thread joined by advice providers with diverse expertise and the lack of empirical evidence for this view points to the gap in our academic understanding of the process by and conditions under which advice seeker will benefit from expertise diversity in an electronic advice network. The team diversity literature suggests that the group processes assumed to help realize the performance potential of expertise diversity in teams may not be present in the context of electronic advice network due to the differences in the characteristics of an advice network vs. a team. In contrast to the intensive and collaborative group-level knowledge integration process expected in a diverse group, in an electronic advice network, it is the advice seeker and his/her team, not the advice providers, who need to process and integrate differences in domain-specific knowledge. Nevertheless, the review of the team diversity literature points to the importance of investigating the communicative interactions in discussion threads with respect to how discussion participants' domain-specific knowledge is communicated and comes to be understood.

CHAPTER 3: THEORY AND HYPOTHESES

In order to better understand how and under what conditions the advice seeker benefits or fails to benefit from the diversity of expertise provided in an electronic network, this dissertation focuses on how discussion participants communicate their domain-specific knowledge in discussion threads and how the knowledge comes to be understood. I adapt Carlile's view of knowledge at a boundary to lay a theoretical framework for the research model of this dissertation. In a study of knowledge integration among members of different communities of practice pursuing innovation through joint effort, Carlile (2004) found that the success of knowledge integration depended on the boundaries that needed to be bridged. Carlile identified three properties of knowledge at a boundary between expertise domains: difference, dependence, and novelty. I find it useful to consider the three relational properties when knowledge is communicated across domains because the difference, relevance, and novelty of domain-specific knowledge create both value and challenges for the advice seeker.

Difference in knowledge refers to a difference in the degree of knowledge and/or a difference in the kind of domain-specific knowledge. In homogenous discussion threads (low expertise diversity discussions) the knowledge discussion participants bring in will differ mostly in degree whereas in diverse discussion threads (high expertise diversity discussions) discussion participants' domain-specific knowledge will differ in degree and kind. Differences in the degree and kind of knowledge create differences in terminologies, languages, meanings, and perspectives that are unique to each specialized domain. The second property of knowledge at a boundary was “dependence” in Carlile, but I use the concept of “relevance” instead. In the context of an electronic advice network, the advice seeker will deal with different degrees or types of domain-specific knowledge that are not only interdependent but also supplementary, complementary, and/or contradictory to one another. The term relevance goes beyond dependence and includes these other types of interrelations between domain-specific knowledge. The last property of knowledge at a boundary is novelty. The differences of domain-specific knowledge brought to the discussion and their relevance are the basis of novelty. That novelty is a source of and a barrier to realizing the performance potential of expertise diversity.

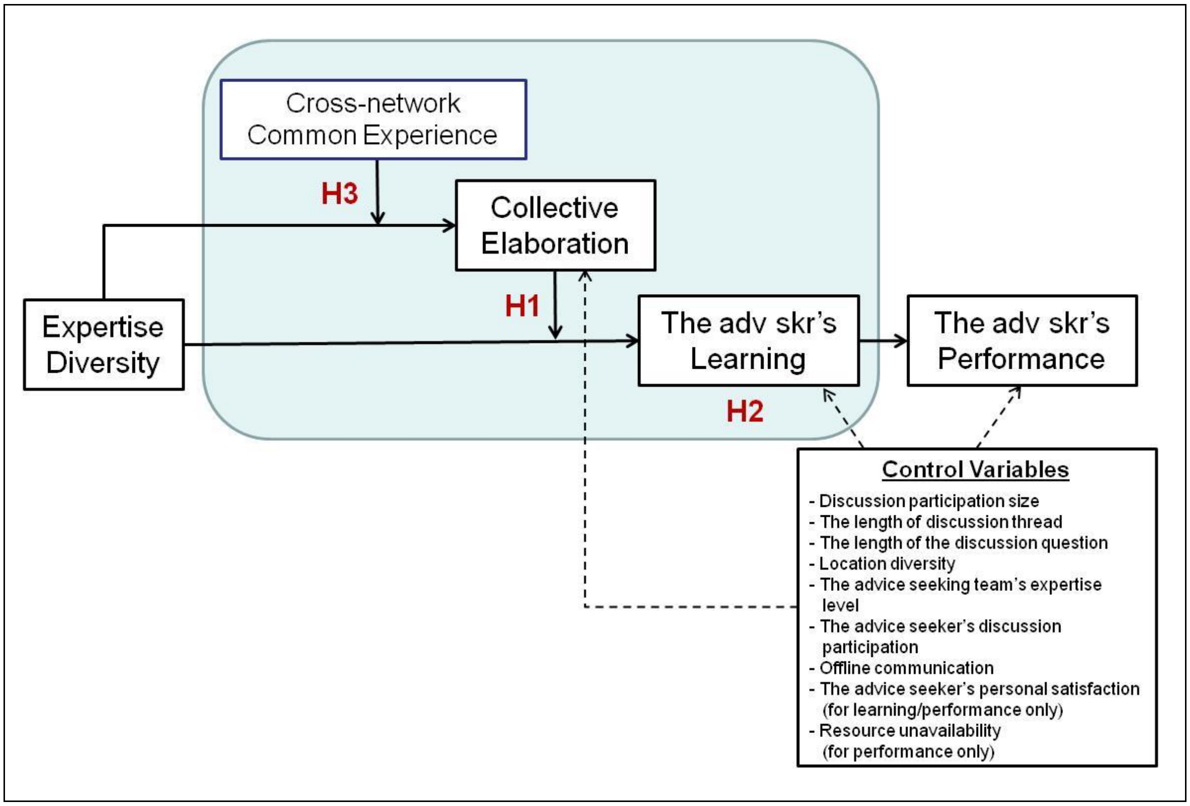
Figure 1 Theoretical Foundation



The three relational properties of knowledge help understand what happens when knowledge is communicated across domains. The more differences exist in the degree and type of domain-specific knowledge among discussion participants, the more beneficial the advice seeker will find the differences (as long as the relevance of the different inputs is well understood), but the less likely that the discussion participants will have enough common knowledge to recognize and understand each other's domain-specific contributions in terms of their relevance. Common knowledge refers to a shared body of knowledge—specifically, shared syntactic and semantic understanding—that is used to present domain-specific knowledge understandably to others and to grasp others' domain-specific knowledge.

The overall research model of this dissertation is presented in Figure 2. The research model aims to unearth the relationship between expertise diversity and the advice seeker's learning and performance outcomes in an electronic advice network. I first introduce the group process, "collective elaboration" as a moderator of the relationship between expertise diversity and learning. Derived from the literature on group-level elaboration, *collective elaboration* refers to a group process through which discussion participants explicate their domain-specific knowledge contribution in detail and the relevance of their domain-specific knowledge to others' contribution. The difference and relevance of the knowledge contribution made by discussion participants are articulated through collective elaboration, creating value for the advice seeker's team. I will provide a theoretical rationale for how collective elaboration moderates the positive and negative effects of expertise diversity on the advice seeker (team)'s learning and on the seeker (team)'s performance outcomes through learning.

Figure 2 Research Model



In addition, I introduce "cross-network common experience" as the condition under which adequate common knowledge, or shared syntactic and semantic understanding, is likely to be present or absent among discussion participants, which determines the likelihood that discussion participants will engage in collective elaboration. Developed from the literatures on knowledge boundary and communities of practice, discussion participants' *cross-network common experience* refers to the extent to which discussion participants have *previously* developed common knowledge of the expertise domains of other discussion participants through regular participation in their respective virtual communities. I propose that the challenges of the syntactic and semantic novelty accompanied by the difference in the discussion participants' domain-specific knowledge contribution are mitigated by the discussion participants' cross-network common experience. I will provide a theoretical rationale for how this construct moderates the relationship between expertise diversity and collective elaboration.

THE ELABORATION PERSPECTIVE ON THE PROCESS UNDERLYING THE RELATIONSHIP BETWEEN EXPERTISE DIVERSITY AND THE ADVICE SEEKER'S TEAM LEARNING AND PERFORMANCE OUTCOMES

The Role of Group-Level Elaboration of Domain-Specific Knowledge

Cognitive theorists suggest that when groups employ *elaborated explanation* as their communicative strategy, groups are more likely to provide opportunities for individuals to achieve learning from elaboration (Webb and Palincsar 1986; O'Donnell and O'Kelly). Adopted from Vandenbosch and Higgins' model building view of learning (1996), learning is defined as the restructuring of a cognitive model to adapt to new knowledge, a new cognitive framework, or a new perspective.

The concept of elaboration was originally developed by educational psychologists: the idea is that a novice learns new knowledge or concepts via a variety of self-elaboration techniques such as "using observations, data, evidence, and background knowledge to support one's opinions and beliefs," "using multiple representations to explain a concept," "providing detailed justifications of the reasoning used to solve problems," and "providing detailed descriptions of how to perform tasks" (Webb and Palincsar 1996). Through self-elaboration, learners thoroughly examine and explore the new knowledge and identify inconsistencies in their assumptions underlying their view of the target concept. By exploring the inconsistencies and making cognitive clarifications, learners are likely to change their mental models and achieve greater learning.

Arguing that learners are unlikely to find these inconsistencies by themselves, Majchrzak and colleagues (2005) advocate the collaborative role of peers in facilitating the learner's learning by providing elaborated explanations of the target concepts themselves through self-elaboration or encouraging the learner to self-elaborate by using the aforementioned self-elaboration techniques. In a study of information systems (IS) development, Majchrzak and her colleagues found that client learning of design requirements significantly increased when developers provided elaborated explanations of their grasp of clients' needs and helped clients to elaborate for themselves. Increase in client learning produced better IS-design outcomes. Similarly, other researchers studying collaborative learning in cross-functional teams suggest that group-level elaboration of knowledge from different domains is critical for group learning and outcomes as it facilitates knowledge integration (O'Donnell and O'Kelly 1994; Olivera and Straus 2004; Mengis 2007; Homan et al 2007; 2008).

Van Knippenberg et al. (2004) suggest that effective integration of knowledge held in diverse groups involves the following group process: individuals bring to the discussion what they uniquely know. Individuals process the information, opinions, and the viewpoints provided by others to understand the implications for their own expertise domain. They feed those implications back to the group. The group then has a better understanding of how each other's unique knowledge should be reconciled and integrated. From the view of elaborating knowledge at a boundary, this process can be understood as the following. In order for knowledge integration across domains to occur, one should clearly communicate one's domain-specific knowledge through elaboration so that others can process it by assessing its difference in relation to their own domain-specific knowledge. Others feed the implications of the contributed knowledge from their own perspective to the group. The implications fed back to the group should elaborate the differences between and the relevance to the previously provided knowledge and their own domain-specific knowledge. To the extent that individuals in the group engage in the cycle of elaborating on the difference and relevance of each other's domain-specific knowledge, it will be easier to integrate their knowledge.

Moderating Effect of Collective Elaboration on the Relationship Between Expertise Diversity and the Advice Seeker's (Team) Learning

Recognizing that group-level elaboration of the difference and relevance of each other's domain-specific knowledge is critical for knowledge integration and learning, I introduce the term *collective elaboration* to refer to a knowledge sharing process through which individuals articulate their domain-specific knowledge contribution not just in depth but also in relation to others' knowledge contribution. The term *collective* is added to emphasize that the effect of elaboration is maximized when the group, not just a few individuals in the group, engages in elaboration.

In an electronic advice network, collective elaboration is present when discussion participants not only explicate their advice in detail in their message but also, more importantly, build upon others' advice by articulating how their different advice relates to the advice previously provided by others. By contrast, collective elaboration is absent when discussion participants' inputs are all isolated or disconnected from each other. Examples of collective elaboration include asking for clarification, clarifying one's advice by providing the reasoning behind it, and validating, extending, challenging, conditioning, or combining other's information, ideas, assumptions, approaches, or perspectives.

I propose that collective elaboration is the primary group process that moderates the relationship between expertise diversity and the advice seeker's team performance outcomes in an electronic advice network. Discussion participants' expertise diversity in discussion threads has a great potential to promote the advice seeker's (and his/her team's) learning by providing a range of diverse knowledge and perspectives. Knowledge integration thrives on specialization and divergence of ideas as long as the decision making team knows how to process and incorporate specialized and divergent inputs into decisions and actions (Eisenhardt and Santos, 2000). Once diverse knowledge and perspectives are well understood through integration, the decision making team will have a better chance to restructure their cognitive model to adapt to the new knowledge provided (Mengis 2007). However, learning will be realized only to the extent that discussion participants engage in collective elaboration so that the advice seeker (team) can better process and integrate their inputs.

Therefore, when the level of collective elaboration is high, I propose that expertise diversity will enhance the advice seeker's (team) learning; that is, the more diverse people join a discussion thread, the more benefit there will be to the seeker's learning, as long as discussion participants engage in collective elaboration. Under this condition, the advice seeker team will learn more from a diverse discussion group than from a homogenous discussion group because they are likely to get exposed to a broader range of domain-specific knowledge that differs in degree and kind while still understanding how the different knowledge is related to each other.

In contrast, when the level of collective elaboration is low, I propose that expertise diversity will not enhance the advice seeker's (team) learning; that is, the more diverse people join a discussion thread, the less benefit there will be to the seeker's learning when discussion participants rarely engage in collective elaboration. If discussion participants do not make an extra effort to build on previous advice or relate their advice to the advice provided by others in the discussion thread, it can be cognitively challenging for the seeker and his/her team to process and integrate the various inputs, particularly when the advice comes from participants from different domains. In high expertise diversity discussion threads, the advice seeker and his/her team may get even confused by different approaches and perspectives given and not know where to focus, or what to act on and what not to, in the absence of collective elaboration. The difficulty of in-depth processing and integration is likely to increase as the diversity of expertise increases, reducing the likelihood of learning. This view is consistent with the finding of Boh, Slaughter, and Espinosa's (2007) study of software development groups, where too much diversity in experience was not necessarily good for the team productivity because team members seemed to have difficulties in relating, reconciling, and integrating experiences across a wide range of domains and adapting them to their task.

When the level of collective elaboration is low, the advice seeker (and his/her team) may actually benefit more from a homogenous discussion group than from a diverse discussion group, although the extent of learning is likely to be incremental rather than substantial. In a low expertise diversity discussion thread, even when the way in which the proposed advice is interrelated is not explicitly articulated, the advice seeker and his/her team would have a reasonable chance to process and integrate them because the discussion participants' knowledge differs mainly in degree but is similar in kind and perspective. Consequently, there are likely to be fewer differences in opinion, approach, and perspective to be reconciled and recombined.

Taken together, I propose that collective elaboration moderates the relationship between expertise diversity and the advice seeker and his/her team's learning in an electronic advice network. Discussion participants' expertise diversity will promote the advice seeker's team learning to the extent that discussion participants explicate their inputs in depth and in relation to others' inputs (a high level of collective elaboration). By contrast, expertise diversity will lower the advice seeker's team learning when there is no collective effort made to understand how one's input is related to another's (a low level of collective elaboration). I formally propose Hypotheses 1 as the following:

> *Hypothesis 1: In an electronic advice network, collective elaboration moderates the relationship between expertise diversity and the advice seeking team learning: this relationship is positive when the discussion participants engage in a high level of collective elaboration, but negative when they engage in a low level of collective elaboration.*

Mediating Role of Learning in the Interactive Effect of Expertise Diversity and Collective Elaboration on the Advice Seeker (Team) Performance

Similar to our understanding of the relationship between expertise diversity and learning, our understanding of the relationship between expertise diversity and the advice seeker's performance has been equivocal. Team diversity research has recently suggested that the result of presence or absence of team learning might affect the relationship between diversity and team performance. In their field study of 62 multidisciplinary face-to-face teams, Van der Vegt and Bunderson (2005) found some (partial) evidence that the relationship between expertise diversity and team performance occurs through integrative learning. If such a relationship holds in an electronic advice network, then the condition under which learning is stimulated or absent will be the condition under which the advice seeker and his/her team will realize (or fail to realize) the performance potential of expertise diversity.

I previously proposed that in a high expertise diversity discussion thread, the advice seeker and his/her team would learn the most when discussion participants engage in collective elaboration but little when discussion participants do not engage in collective elaboration. When the advice seeker's team is exposed to a well elaborated set of diverse information and perspectives, the likelihood that the team expands the scope of its thinking about the problem under discussion and challenges its perspective and initial assumptions will increase (e.g., Majchrzak et al, 2005). The need to reconcile and recombine different knowledge and viewpoints, including their own, will force the advice seeker's team to more thoroughly process them and prevent the team from opting too easily for a course of action the team may have initially or tentatively conceived of (van Knippenberg et al., 2004). Various theories and research have suggested that learning leads to better group performance because it triggers behavioral changes that bring more valuable reorientations to their performance (e.g., Edmondson, 1999; Majchrzak et al, 2005; Boh et al., 2007).

Therefore, in order for the advice seeker and his/her team to realize the performance potential of expertise diversity of an electronic advice network, the team needs to learn from the diverse knowledge shared in the discussion thread. Whether the advice seeker and his/her team achieve greater learning from the discussion participant's domain-specific knowledge is contingent on the level of collective elaboration, and when learning does occur, it leads to better team performance.

Taken together, I propose the following hypothesis.

Hypothesis 2: In an electronic advice network, learning fully mediates the moderated effect of expertise diversity and collective elaboration on the advice seeking team performance.

If the mediating role of learning exists as hypothesized, the interactive effect of expertise diversity and collective elaboration on performance will no longer be expected once the effect of learning is controlled for.

ANTECEDENT OF COLLECTIVE ELABORATION: CROSS-NETWORK COMMON EXPERIENCE

At the heart of collective elaboration lies the understanding and externalization of differences and relevance of ideas and perspectives. As Jung and Boland (2009) show in their case study of online forums, however, not all diverse discussion groups exhibit this kind of elaboration process. In one observed discussion thread, it was reported that someone attempted to offer a solution to the problem under discussion while discrediting, but with unclear justification, what a few others had collectively come up with before. The participant's input ended up confusing the advice seeker.

In order to understand and externalize the differences and relevance of domain-specific knowledge, Carlile (2002) suggests that actors need to have common knowledge that can be used to present domain-specific knowledge such that the syntax and meanings conveyed are understandable to others and to assess others' domain-specific knowledge. If there is common knowledge between communicating parities, that is sometimes called *common ground* (Clark 1996). When the level of common ground is high, communicating individuals use terms, concepts and meanings that are mutually understandable and allow for little misinterpretation. It should be noted that, in this dissertation, the presence of common ground between communicating parties does not necessarily mean that their assumptions and perspectives are congruent. Rather, common ground primarily concerns mutual understanding of one another's syntactics and semantics, which permits communicating individuals (discussion participants) to present their domain-specific knowledge understandably and to make sense of the concepts, meanings, and perspectives reflected in the language (messages).

Syntactic and Semantic Boundaries Inhibiting Collective Elaboration and Common Ground

Carlile (2004) outlines syntactic and semantic boundaries as significant barriers to develop adequate common knowledge needed for individuals when they engage in knowledge sharing across communities of practice.[2] Differences in domain-specific knowledge expose syntactic and semantic novelty when knowledge is communicated

2 There is another boundary called a pragmatic or political boundary, which I exclude from discussion in this paper. This boundary arises when different interests and goals among participants are in conflict and generate costs to the actors involved, including transforming their knowledge. An existing pragmatic boundary has to be resolved, often politically, through negotiation if the objective is to develop a course of action all actors abide by. This boundary is irrelevant to the focus of this study (advice seeking and providing).

across domains. Communicating parties experience difficulty in transferring other's domain-specific knowledge due to a syntactic boundary when they use a distinct lexicon of terminologies, concepts, and codes. In an ethnographic study of how the understandings of individual communities of practice are successfully communicated across workgroups, Bechky (2003) found that one of the difficulties in sharing knowledge across technically oriented communities was rooted in differences in language. For instance, engineers spoke the precise and standardized language of drawings but only had a simple understanding of assemblers' language of the physical machine. Similarly, the assemblers' language was embedded in the concrete context of building a machine and their vocabulary referred to the physical and spatial aspects of the machine. However, they understood very little of the conceptual drawing language used by engineers.

In addition, communicating parties may also experience difficulty in translating knowledge due to a semantic boundary when encountering differences in the meaning of concepts and their interpretations (Brown and Duguid 1991; Cronin and Weingart 2007). Because of the specialization inherent in performing their own tasks, communities of practice develop their own "thought worlds" (Fleck 1979) or "interpretive schema" (Boland and Tenkasi 1995), which shape perspectives local to particular communities, not to mention lexicons and meanings (Brown and Duguid 1991). Dougherty (1992)'s field work on "thought worlds" provides insight as to why differences in meaning across specializations remain challenging; different thought worlds made it difficult to exchange knowledge that differed in kind because people use different meanings and interpretations of the same concepts.

Taken together, the syntactics and semantics developed and used within communities can create a barrier to cross-community knowledge sharing by making it difficult to understand different domain-specific knowledge.

Accordingly, in the case of high expertise diversity discussion threads where advice providers are from various expertise domains, it is possible that some domain-specific knowledge may not only be expressed in different terminologies, but the meaning of concepts and their use may also be embedded in a specific practice or context, requiring deeper understanding, and not just a common lexicon. Not only might the same concept be used in different ways, but also any particular term may not be universally understood and interpreted. These boundaries would then make it difficult for discussion participants to understand and build upon previous replies conveying knowledge that differed in kind. Without some level of shared syntactic and semantic understanding, or common ground, discussion participants will not be capable of translating different domain-specific knowledge (Carlile 2004), a prerequisite to engaging in collective elaboration.

Research on cross-functional teams has generally conceptualized common ground as growing out of a course of action. The traditional view of common ground is that common ground can be updated and accumulated over time through the process of "grounding" (Clark and Brennan 1991). Cross-functional teams (i.e., high expertise diversity situations) typically have a low level of common ground to begin with. Little common ground is, however, not a serious threat to effective communication and knowledge integration in face-to-face teams because members accrue common ground over time through rich and extensive interactions (Bechky 2003). The establishment of common ground often starts with the initial recognition of the cognitive incompatibilities created from syntactic and semantic boundaries existing between communicating parties. The communicating parties then make mutual effort to transform their local understandings by grounding their mismatched languages and meanings in a physical space. They then create shared understandings through joint use of boundary objects such as physical equipment, CAD models, and software applications and codes (Tyre and von Hippel 1997; Carlile 2002; Bechky 2003; Pawlowski and Robey 2004; Levina and Vaast 2005; Gopal and Gosain 2009). For instance, Bechky (2003) illustrated in detail how engineers, assemblers, and technicians reconciled their initial misunderstandings over time by physically demonstrating their problems with the use of boundary objects like a pump and engineering drawings, which provided the context needed to create shared syntactic and semantic understanding.

The traditional view of common ground as growing through rich and extensive interactions is, however, less likely to apply to the context of an electronic advice network. As previously pointed out, advice providers do not exhibit the same level of intensive and iterative group-level information processing as would be seen in traditional workgroups, due to open participation and the lack of pressure for knowledge integration through reconciliation. People enter and leave a discussion at any point of time and this fluidity of participation makes common ground building unsustainable. Little pressure for synthesis gives little incentive for discussion participants to make an effort to relate their advice to previously provided advice particularly if they do not share some level of syntactic and semantic understanding.

For these reasons, I argue that common ground is *a static state*, rather than being buildable, in an electronic advice network. In order for advice providers from different domains to be able to engage in collective elaboration during discussion, there has to be some level of common ground, or shared syntactic and semantic understanding, *to begin with*. If advice providers enter a discussion thread and do not understand the lexicons or meanings of previously provided contributions, they will not be able to build on them.

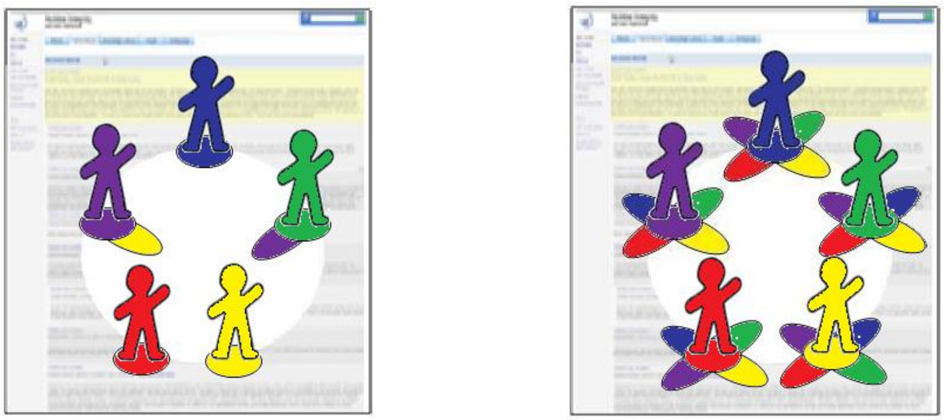
Cross-network Common Experience: Breadth of Shared Syntactic and Semantic Understandings

How can we then predict whether discussion participants will be able to engage in a high or low level of collective elaboration in a high expertise diversity discussion thread? I propose that discussion participants' cross-network common experience reflects the level of common ground particularly in a high expertise diversity discussion thread. *Cross-network common experience* refers to the extent to which discussion participants as a group, on average, have *previously* developed syntactic and semantic understanding of the expertise domains of the other participants in a given discussion, through regular participation in all their respective virtual communities. Discussion participants' cross-network common experience is a group-level construct that reflects the breadth of discussion participants' shared syntactic and semantic understanding of all the expertise domains represented in the discussion thread. The expertise domains represented in a discussion thread are the expertise domains in which discussion participants specialize.

Each discussion participant's syntactic and semantic understanding of the several expertise domains represented in a discussion thread is likely to vary. Some participants may be narrow specialists, with exposure only to their own expertise domains, and others may be broad generalists, with exposure to all or most of the expertise domains represented in the discussion thread. Adopting the distinction of specialists and generalists from Bunderson and Sutcliffe (2002), I use the composition of specialists and generalists in a discussion thread as the basis to estimate the breadth of shared semantic and syntactic understanding among the discussion participants. The discussion participants' cross-network common experience is narrow when the discussion thread comprises narrow specialists and broad when it comprises broad generalists. The distinction between narrow specialists and broad generalists is more important in a high expertise diversity discussion thread than in a low expertise diversity discussion thread because the number of domains represented in a low expertise diversity discussion thread is very small.

To help understand the concept of cross-network common experience, Figure 3 illustrates two discussion threads with the same level of expertise diversity but with different breadths of shared syntactic and semantic understanding. Both discussion threads have five participants, each from a unique expertise domain. Color represents an expertise domain, a circle represents an individual's main expertise domain, and ovals represents the domains of which an individual has syntactic and semantic understanding.

Figure 3 Narrow vs. Broad Cross-network common experience



Narrow cross-network common experience

Broad cross-network common experience

The discussion thread on the left is full of narrow specialists: three have been exposed only to their own domains (e.g., blue, red, and yellow participants) and two are familiar with one more domain besides their own. In contrast, the discussion thread on the right is full of broad generalists: everyone is familiar with all five domains represented in the group. Consequently, in the discussion thread on the left, the discussion participants' cross-network common experience is considered narrow, because the breadth of the participants' shared syntactic and semantic understanding is narrow (i.e., there is little overlap), whereas in the discussion thread on the right, the discussion participants' cross-network common experience is considered broad, because the breadth of shared syntactic and semantic understandings is broad (i.e., there total overlap).

In knowledge-intensive firms, knowledge workers are often affiliated with multiple teams as their organization becomes more geographically distributed and project-based (Mortensen et al. 2008); work is hardly done in functional silos but rather through interfaces with other domains to some or great degree (Dougherty 1992; Kellogg et al. 2006). Thus, there is a strong need to work across different but related domains and be able to transfer and translate knowledge rooted in other domains.

Regular participation in a cross-domain community of practice offers employees learning opportunities of the syntactics and semantics used by others. Brown and Duguid (1991) describe the process by which individuals are enculturated through participation in a community of practice as the individuals "acquire a particular community's subjective viewpoint and learn to speak its language" (p. 48). Shared perspectives and focused areas of interest are likely to get formed, refined, and even reinforced among members within a community, presented in language that is shared and comprehensible to its members (Brown and Duguid 1991; Dougherty 1992; Kellogg et al. 2006; Dickey et al. 2007). Lave and Wenger's (1990) notion of "legitimate peripheral participation" suggests that as newcomers become involved in a community of practice, they gradually learn not just norms and appropriate work behaviors but also the syntactics and semantics specific to the community.

When individuals have gained syntactic and semantic understanding of other domains besides their own through participation in related communities, they will have more adequate common knowledge to represent their domain-specific knowledge understandably to people in other domains and to assess the differences between their own knowledge and other's knowledge and their relevance (Aldrich and Herker 1977; Tushman and Scanlan 1981).

A firm's internal virtual communities provide employees easy access not just to their main expertise domain but also to other "sister" domains, offering opportunities to develop syntactic and semantic understanding of other domain-specific knowledge. By additionally participating in "non-home" virtual communities specialized in other domains besides their own, employees can learn about what is going in those adjacent fields. They also become gradually familiar with the language, meanings, and perspectives specific to these domains by being exposed to and learning from discussion topic threads, online newsletters, codified knowledge such as best practices, lessons learned, and technical manuals retained in the respective communities' portals. Consequently, while it would be difficult to acquire technically sophisticated expertise and perspective at the same levels of the core members of these "non-home" communities, they can, at least, carry on meaningful conversation with the core members, based on shared syntactic and semantic understanding, after having regularly participated in those communities for some time.

Moderating Effect of Discussion Participants' Cross-network Common Experience on the Relationship between Expertise Diversity and Collective Elaboration

Building on the previous sections, I present the relationships among discussion participants' cross-network common experience, expertise diversity, and collective elaboration. In high expertise diversity discussion threads, when discussion participants' cross-network common experience is narrow, the participants will be less able to engage in collective elaboration because of low common ground. In this case, most discussion participants are narrow specialists, who lack syntactic and semantic understanding of the others' domain-specific knowledge provided in the discussion. They will not have adequate common knowledge that enables them to understand others' advice nor will they be able to articulate their own advice in ways that others can grasp. In contrast, when discussion participants' cross-network common experience is broad, the participants will be more able to engage in collective elaboration because of high common ground. When a discussion thread is dominated by broad generalists who have shared syntactic and semantic understanding of each other's expertise domain, they will be better at recognizing the relevance of their inputs, thus more likely to engage in collective elaboration.

On the other hand, in the case of low expertise diversity discussion threads, discussion participants' cross-network common experience, whether narrow or broad, will not affect the level of collective elaboration to the same degree as in the case of high expertise diversity discussion threads. In a low expertise diversity discussion thread, because the number of domains represented is small, the level of common ground might be moderate or high, but because of the small number of domains, there is much less room for elaboration. Because the majority of the participants share knowledge that differs only in degree but little in kind, the focus of collective elaboration will be mostly limited to validation, clarification, and incremental extension of ideas.

Figure 4 An electronic advice network associated with different combinations of expertise diversity and cross-network common experience

Expertise Diversity

Cross-network common experience

Narrow — **Low**

D1	A	B
Adv seeker		V
Adv prvdr 1		V
Adv prvdr 2		V
Adv prvdr 3	V	
Adv prvdr 4		V
Adv prvdr 5		V
Adv prvdr 6		V

Narrow — **High**

D2	A	B	C	D
Adv seeker			V	
Adv prvdr 1	V		v	
Adv prvdr 2				V
Adv prvdr 3				V
Adv prvdr 4		V		
Adv prvdr 5			V	
Adv prvdr 6	V			

Broad — **Low**

D3	A	B
Adv seeker	v	V
Adv prvdr 1	v	V
Adv prvdr 2		V
Adv prvdr 3	V	v
Adv prvdr 4	v	V
Adv prvdr 5	v	V
Adv prvdr 6	v	V

Broad — **High**

D4	A	B	C	D
Adv seeker	v	v	V	
Adv prvdr 1	V		v	v
Adv prvdr 2	v		v	V
Adv prvdr 3	v	v	v	V
Adv prvdr 4		V	v	v
Adv prvdr 5	v	v	V	v
Adv prvdr 6	V		v	v

A, B, C, D	Expertise Domain
V	Home Community
v	Non-home Community

To help understand the proposed relationships, Figure 4 displays four different types of discussion threads characterized by varying levels of expertise diversity and cross-network common experience. For simplicity, I confine the number of advice providers to 6 and expert domains to 4 (A, B, C, and D). Each quadrant represents a discussion thread composing of one advice seeker and 6 advice providers (listed in the order of reply). ‘V’ represents a discussion participant’s main expertise domain (determined by his or her “home” community’s specialization; one considers a community as “home” if the community’s specialization most closely matches one’s main expertise domain). ‘v’ represents a domain that a discussion participant has syntactic and semantic understanding of (by having regularly participated in this “non-home” community).[3]

In discussion threads full of broad generalists, I expect to see *higher* levels of collective elaboration when expertise diversity is high (D4) rather than low (D3). In the low expertise diversity discussion thread (D3), collective elaboration would occur mostly around limited domains (A and B), but in the high expertise diversity discussion thread (D4), discussion participants will more room to engage in collective elaboration (A, B, C, and D). For instance, Advice Provider 2 in D4 understands Provider 1’s input and crafts her reply in relation to Provider 1’s input. Provider 3 sees what has been discussed and extends Provider 2’s advice. Provider 4 understands where Providers 2 and 3 are coming from but disagrees and explains why. Shortly after, Provider 5 corrects Provider 4’s opinion by articulating the conditions under which Provider 4’s suggestion works. As such, high expertise diversity discussion threads full of broad generalists might trigger and benefit most from collective elaboration. Thus, in discussion threads full of broad

[3] It should be noted that some discussion participants may also be, for instance, members of communities specializing in other domains E, F, or G. I do not take these cases into account because I assume that the participants’ syntactic and semantic understanding of the domains contributes little to what is discussed in the given threads (i.e., the discussion is largely limited to domains A, B, C, and D).

generalists, it seems quite possible that there is a positive relationship between expertise diversity and collective elaboration.

In discussion threads full of narrow specialists, on the other hand, I expect to see *lower* levels of collective elaboration when expertise diversity is high (D2) rather than low (D1). In the case of low expertise diversity discussion thread (D1), collective elaboration will occur mostly around a single domain (A). In the case of high expertise diversity discussion thread (D2), the likelihood that the participants will engage in collective elaboration is low. For instance, Providers 2 and 3 both reply to the advice seeker's query, but their replies contain no reflection on Provider 1's idea because they both do not understand it. Providers 4 and 5 later join the discussion and provide advice but disconnected from the others' for the same reason. Provider 6 comes in and adds her thought on Provider 1's comment only. The participants provide diverse inputs, but collective elaboration does not actively occur due to low common ground. Thus, in discussion threads full of narrow specialists, it seems quite possible that there is a negative relationship between expertise diversity and collective elaboration. My arguments so far are summarized in the following table.

Table 2 Summary of the Relationships in Figure 4

Discussion in Fig. 4	Expertise Diversity	Cross-network Common Experience	Collective Elaboration
D1	Low	Narrow	Med
D2	High	Narrow	Low
D3	Low	Broad	Med
D4	High	Broad	High

Taken together, I formally propose the following hypothesis:

Hypothesis 3: In an electronic advice network, discussion participants' cross-network common experience moderates the relationship between expertise diversity and collective elaboration: the relationship is positive when the level of cross-network common experience is broad, but negative when the level of cross-network common experience is narrow.

The traditional view of common ground suggests that discussion participants in a high expertise diversity discussion, even when they are narrow specialists, eventually will exhibit collective elaboration because they can develop shared syntactic and semantic understanding through interactions. If the traditional view of common ground as being buildable over time holds true in discussion threads, I will find no support for Hypothesis 3.

SUMMARY OF THIS CHAPTER

This chapter aimed to unearth the complex relationships between expertise diversity and the advice seeker's (team) learning and performance in an electronic advice network by focusing on how the difference, relevance, and novelty of knowledge at a boundary create both opportunities and challenges to the communication and understanding of discussion participants' domain-specific knowledge. Building on the literature on elaboration, on the one hand, I proposed that expertise diversity would be problematic for the advice seeker's team learning and performance without collective elaboration. Collective elaboration is present when discussion participants articulate the differences and relevance of their domain-specific knowledge. The advice seeker and his/her team would benefit the least when the discussion is highly diverse but lacks collective elaboration. Building on the theories on knowledge boundaries and communities of practice, on the other hand, I proposed that the novelty of domain-specific knowledge would impede collective elaboration in high expertise diversity discussion threads if discussion participants had not possessed shared syntactic and semantic understanding of each other's expertise domains; only when the discussion participants had a high level of cross-network common experience, they would be able to engage in collective elaboration. Cross-network common experience refers to the extent to which discussion participants as a group, on average, have *previously* developed syntactic and semantic understanding of the expertise domains of the other participants in a given discussion, through regular participation in all their respective virtual communities.

CHAPTER 4: RESEARCH METHODOLOGY

In this chapter, I present the field research site, data collection procedures, construct measures, the validities and reliabilities of the measures, and the analyses by which the hypotheses presented in Chapter 3 were tested.

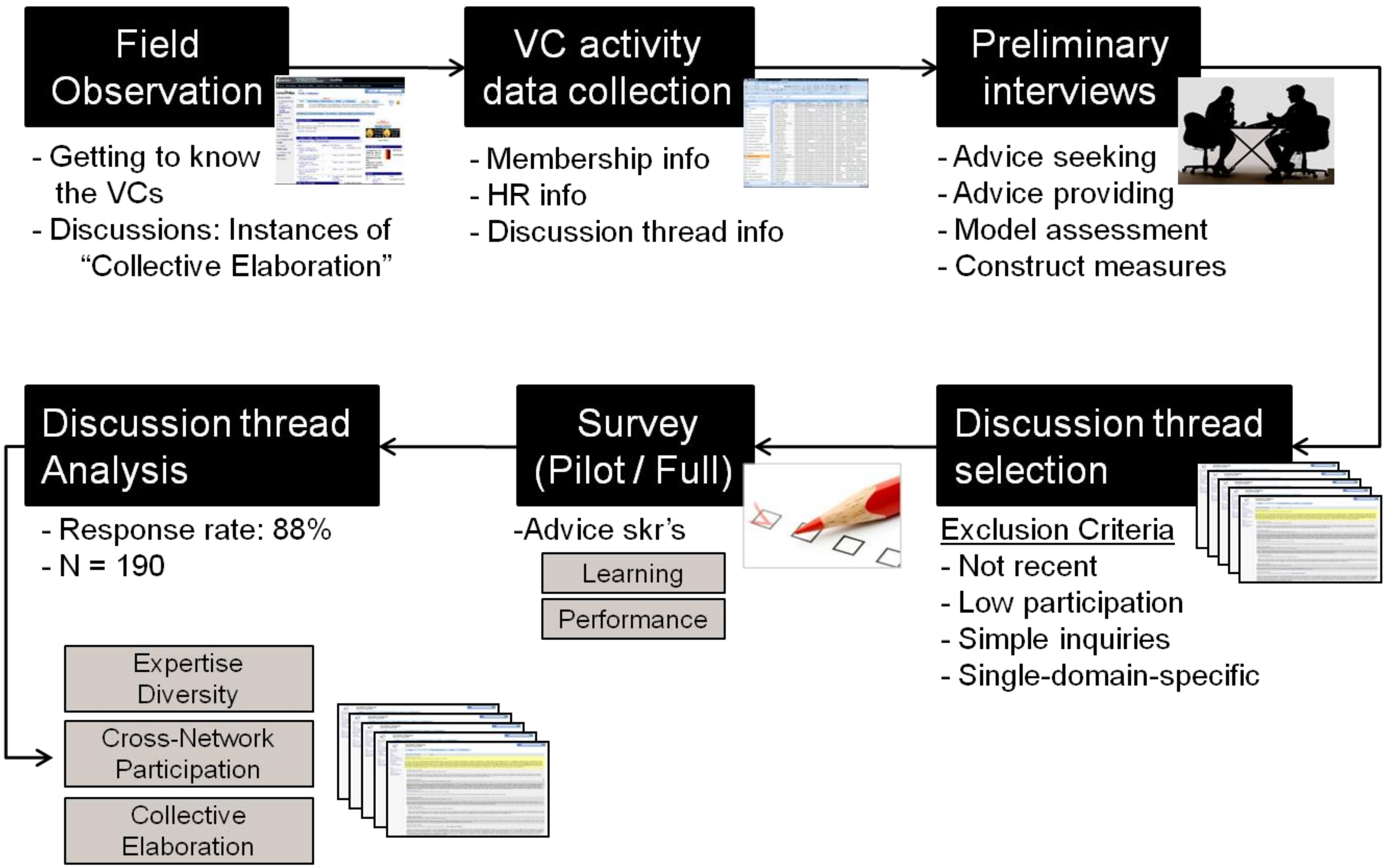
RESEARCH SITE

I tested the proposed hypotheses using data obtained from a firm that was running a network of internal virtual communities of practice. I decided to test my research model in one organization rather in multiple organizations so that I could hold constant a number of contextual factors that might influence the hypothesized relationships such as how performance was measured and how discussion was shared across communities. I could thus focus on the hypothesized relationships while minimizing variance on many of the more common organizational and industry confounds (e.g., company policies and organizational norms regarding knowledge sharing, the types and nature of expertise domains in the industry).

The field site is a global energy company, headquartered in the Southern U.S. with more than 30,000 employees worldwide, operating in the oil and gas industry. This company was selected as my research site because 1) the company received extensive media attention and industry-wide recognition for running its internal virtual communities successfully (in terms of systematic and disciplined management, active participation and sustainability, and positive sentiments toward knowledge sharing), so this controls for poor management of the communities; 2) members of the virtual communities were using online discussion forums actively and there were many discussion threads involving members of different virtual communities, providing a perfect opportunity to test the research model; and 3) the director of the Knowledge Sharing Group managing the virtual communities was supportive of my field study and permitted data collection at his company.

As of July 2010, there were over 130 communities, each functioning under management sponsorship with specific business objectives (see Appendix I: Background of the Virtual Communities at the Research Site for more information). Each community was organized around a specific domain of expertise (specialization), spanning geographic and time zone boundaries. Some 12,000 employees (or nearly 75% of employees identified as knowledge workers) were participating in the communities. On average, a user was a member of 2.36 communities (SD = 2). 50% of the users had membership in just one community, 30% were members of two, 20% were members of three, and 10% were members of more than three communities. Community membership ranged from 100 to 900 members per community.

Figure 5 Overview of Data Collection and Analysis



DATA COLLECTION

The overall data collection (and analysis) procedure is illustrated in Figure 5 (See Appendix II Data Collection and Analysis Timeline for more information) Besides collecting secondary data, both quantitative and qualitative, I employed several methods, including field observation, interview, and survey, to collect different types of primary data. In this section, I describe the steps I went through to collect data.

Preliminary Field Observation

Once I had a remote access to the field site's Intranet, I regularly visited the virtual communities' web portals for two months (May and July 2010). Figure 6 illustrates an example of a virtual community's web portal from which members as well as visitors can access the community's discussion forum ("Ask and Discuss"), knowledge repository ("Knowledge Library"), member list ("People"), workgroups, and general community information ("News and Announcements," "Events," "About the Network"). I familiarized myself with the web portals by exploring the structures of the communities and the various activities going on within and across communities.

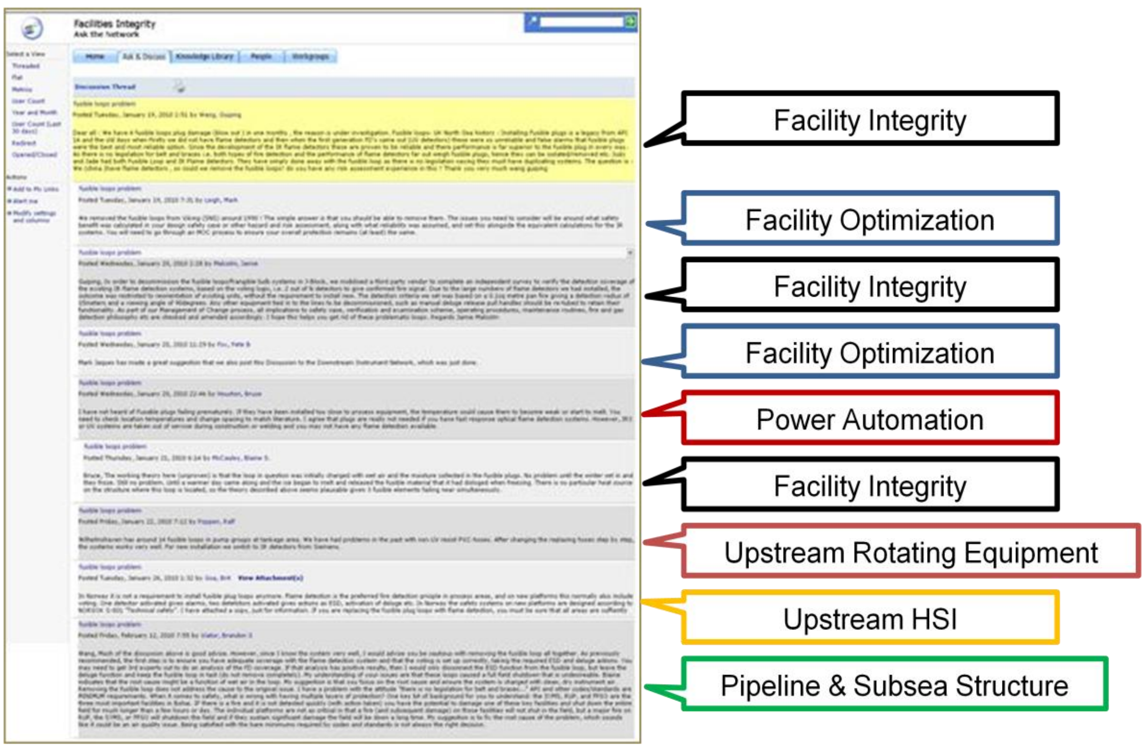
Figure 6 Example of a Virtual Community's Web Portal

Once I had a good understanding of what the communities were about and how knowledge was shared, I began reviewing a set of discussion threads (which were not part of my data set for formal analysis—see the section on Eligible Discussion Thread Selection Criteria, below, for more information on which discussion threads were eligible for the formal analysis).

Figure 7 provides a typical example of a discussion thread joined by members of various communities (participants from various expertise domains). As shown in Figure

7, an advice seeker posted a question about a technical issue on behalf of his project team to seek a technical advice from experts across the company so that the team could make a better informed decision to solve the issue. The discussion thread was initiated on a discussion forum of one community (Facility Integrity), but soon joined by members of not only the Facility Integrity community but of other communities as well.

Figure 7 Snapshot of a Discussion Thread



The purpose of my reviewing discussion threads was to produce a list of representative instances of collective elaboration to be used as the basis for developing the coding scheme for collective elaboration. The review was an iterative process, going back and forth between the literature on elaboration and the data, and the list was later finalized based on feedback from interviewees.

Table 3 Secondary Data Types

Information	Type	Specifics	Note
Community membership information	Member list	Role	
		Enrollment date	
	Members' VC activities	Readership	Visit (log-in) data over the span of 6 months
		Discussion participation	History of advice seeking and providing in the discussion forum
		Knowledge repository entries	Number of document uploading
Members' HR information	Contact info	Name	
		Email-address	
		Work location	City and Country
	Org info	Work title	
		Department name	
		Organizational Level	Number of layers from the CEO
Discussion thread information	Discussion topic	Hosting VC	The discussion thread's VC
		Discussion title	
		Post date	
		Advice seeker info	VC Membership/HR info
		Cross-posted [Y/N]	Whether the thread is posted in other communities
	Discussion content	Advice provider info	VC Membership/HR info
		Reply contents	

Secondary Data Collection

With the help of the Knowledge Sharing Group, I collected various items of secondary data related to community membership, participants' personal HR information, and discussion threads. Table 3 describes the secondary data I collected in detail. These data were used to measure “expertise diversity,” “cross-network common experience,” and a number of controls.

Pre-Survey Interview

I conducted semi-structured interviews with 16 employees (14 face-to-face interviews on site and 2 phone interviews) with the help of the director of the Knowledge Sharing Group in July 2010 (See Appendix III for the list of the interviewees). From my preliminary analysis of the virtual communities data, I was able to identify community leaders, advice seekers, and advice providers who were among the most active in discussion participation. The interviews lasted from 30 minutes to 90 minutes. I asked several questions related to the following topics during the interview:

- Motivation to participate in virtual communities
- Motivation to participate in an online discussion (“Ask and Discuss”) (either as an advice seeker or provider)
- Views on and experience with online discussion
- The effects of expertise diversity on learning and performance outcomes
- Collective elaboration
- Participation in multiple virtual communities as a member

I used the interviews 1) to assess the practicality of my research question and my research model, 2) to refine my coding scheme for collective elaboration, and 3) to revise my survey questions. For instance, my observation and interviews did not find any evidence that discussion participants engaged in an intensive and collaborative group-level knowledge integration process as expected in a diverse group according to the team diversity research. Instead, I found support for the notion of collective elaboration as an appropriate group process that facilitates "dialogue" in the discussion and helps the advice seeker's learning and performance. I brought with me select discussion threads in which some of the interviewees had previously participated. I asked them to assess the threads from the collective elaboration perspective. With this feedback from the interviewees, I revised my collective elaboration coding scheme. I also modified the survey questionnaire and added performance-related items to make the survey items more company-specific.

Eligible Discussion Thread Selection

This dissertation mainly concerns discussion threads in which the advice seeker may potentially benefit from advice providers with diverse expertise. I used the following "exclusion" criteria in my selection of a pool of discussion threads eligible for this study.

- Discussion threads that were older than 7 months (initiated before 2010)
- Discussion threads that had low participation (less than three replies)
- Discussion threads that were based on simple inquires
- Discussion threads that were single-domain specific

The reason for the first criterion was to make sure that survey respondents still had a vivid memory of the specific discussion following their question and the impact of the discussion on their team learning and performance outcomes. The second criterion (less than three replies) was based on the input I received from interviewed community leaders as the threshold for having potentially meaningful discussion. The third criterion was to make sure that discussion participants dealt with complex and non-routine issues as opposed to simple inquires. Specifically, I omitted discussion threads in which advice seekers asked, as was apparent from their inquires, for yes/no answers, references, documents, or existing data. I also omitted discussion threads where the apparent objective was to gather factual information on site-specific practices or resource availability. The reason for the fourth criterion was to make sure that I studied discussion threads in which advice seekers could potentially benefit from diverse inputs from different expertise domains. This way, I could examine the conditions under which expertise diversity benefits, or more interestingly, fails to benefit the advice seeker. I had two ways to assess this criterion. First, for each discussion thread, a community leader indicated whether the question posed on his/her discussion forum was of interest/relevance to the members of other communities.[4] Second, later in the survey, I asked the survey respondents whether they thought that their question was of interest or relevance to the members of more than one community. When both community leader and survey respondent agreed that the question was of no interest/relevance to members

[4] Once a member poses a new inquiry on the discussion forum of his or her virtual community, the community leader decides whether to share the new discussion thread with some other communities in case the inquiry seems to benefit from inputs from them. Members of the selected communities can then see the new discussion thread cross-posted to their community web portal's discussion forum. My analysis shows that this type of selective invitation facilitates participation not only from the selected communities but also from other "uninvited" communities. The latter is possible because of word of mouth, RSS feed, and individuals' membership in multiple communities.

of other communities, I excluded the respective discussion thread from my pool. Eventually, I identified 276 eligible discussion threads after applying the exclusion criteria. The identified pool was a set of relatively recent, active discussion threads triggered by problem solving / decision making seeking-inquires that were potentially (or actually) multi-domanial. From this pool, I identified 255 unique advice seekers (associated with 255 unique discussion threads), who became the target survey participants of my study.

Survey

Based on the relevant literature and feedback from the interviewees, I designed a survey questionnaire to ask the identified survey participants (advice seekers) to rate their own advice seeking experience specifically in relation to the discussion thread initiated by their question. Multi-item constructs such as the advice seeker's team learning and performance outcomes and several controls were measured via the survey. To make sure that the survey participant was sufficiently reflective on a particular discussion thread (usually the most recent discussion thread he or she initiated), I included the survey participant's question and the associated discussion thread (including all replies) at the beginning of the survey. I also added a survey question to confirm whether the survey participant had reviewed his or her discussion thread before beginning to answer the survey questions.

Pilot Test

I administered a pilot survey in August 2010. Fifty discussion threads that met the criteria above were randomly chosen from the pool and their respective advice seekers were invited via internal email to complete a pilot survey. The Director of Knowledge Sharing Group sent the invitation email to the selected 50 employees. In his email, he explained the purpose of the survey and encouraged the invitees to participate. I used the online survey tool provided by Qualtrics. I chose to use Qualtrics because it allowed me 1) to personalize my instruction email and survey questionnaire so that they contained survey respondent-specific information and 2) to track who responded and who did not. These two features were crucial for my data analysis because I had to relate discussion threads to their respective advice seeker survey as well as to the secondary data specific to the discussion thread. Twenty nine advice seekers participated in the pilot survey.

The main purpose of the pilot survey was to find out whether survey participants found any question ambiguous, inapplicable, or difficult to answer or if they had any suggestion to improve the completeness, readability, and clarity of the survey questionnaire. Another purpose was to make sure that the responses showed sufficient variation. I revised the survey based on the feedback and responses I got from the 29 participants.

Full-scale Survey

I conducted a full-scale survey in September 2010. A survey invitation email was sent by the director of the Knowledge Sharing Group to 227 employees (advice seekers) whose discussions I identified as eligible for this study.[5] Following the invitation email, I sent out a survey instruction email to the target survey group (see Appendix VI: Survey Instruction Email). The survey was administered for three weeks (see Appendix V: Survey Questionnaire). During the administration period, I sent out two reminders to those who had not completed the survey. Five invitees were unavailable for the survey (four had left the company and one declined to participate). In all, 196 survey questionnaires were submitted, but one was dropped due to incomplete response. Thus, the response rate was 88% (196 out of 223). No significant differences in expertise diversity, cross-network common experience, and collective elaboration measures were found between the response group (N=196) and the non-response group (N=27). Five of the 195 complete survey questionnaires were omitted from the final analysis because the five discussion threads were found to be single domain-specific (this was agreed to by both the survey respondents and respective community leaders). In sum, the final sample for this study consisted of 190 discussion threads.

CONSTRUCT MEASURES

Expertise Diversity

Expertise diversity was computed from archival data, using discussion participants' expertise domains indicated by their "home" community's specialization. Previous studies have often used functional areas or educational background as an

[5] There were some 20 more eligible discussion threads, but the advice seekers of these threads had already been invited to complete the survey to rate other discussion threads.

indicator of expertise domain (see Bunderson and Sutcliffe 2002 for a review), but this indicator has been often criticized as a crude measure of actual specialization or expertise (Van der Vegt and Bunderson 2005). I believe membership in the "home" community is a good indicator of a participant's expertise domain because: 1) the virtual communities I studied in this organization were organized around specific domains of expertise; 2) the management made sure that there was no redundancy between communities in terms of focused domains— a proposal for a new community was rejected if there was an incumbent community with similar focus and objectives, and 3) members of virtual communities were invited for cross-network discussions just because of the core specializations their communities uniquely represented. Furthermore, in my interviews, I learned that everyone had what he/she considered a "home" community, of which specialization most closely matched his or her main expertise domain.

I assumed that if one was a member of more than one community, one's "home" community was the community in which one had participated most actively; I used the discussion participants' virtual community activity information (Table 3) to identify everyone's "home" community. Specifically, I assessed his/her discussion participation and knowledge repository entries in each of the virtual communities of which he/she was a member and readership (i.e., how frequently and consistently he/she had visited the communities in the previous 6 months before the discussion). In most cases, one's home community clearly stood out. There were 26 participants who had actively participated in more than one community, making it difficult to identify their home communities. In these cases, I choose their home communities based on their department affiliation and work title. In summary, there were 63 unique expertise domains (i.e., home communities) represented by 1,200 discussion participants (692 unique participants) in the 190 surveyed discussion threads. The number of unique expertise domains represented in a discussion thread ranged from 1 to 7 in this study.

I used Blau's (1977) index of heterogeneity, $1 - \sum_{i=1}^{n} p_i{}^2$, a widely adopted diversity index in team diversity research, to compute the expertise diversity of a discussion thread. In this formula, p is the proportion of discussion participants who belong to a specific specialization, or expertise domain, category and i is the number of different specialization categories represented in the discussion thread. n refers to the total number of specializations represented in the discussion. A higher index score indicates greater expertise diversity among discussion participants. Expertise diversity within a discussion thread is maximized (i.e., diversity = 1) when everyone has a different home community and is minimized (i.e., diversity = 0) when participants all share the same home community. For instance, in Figure 4, the expertise diversity in discussion threads D1 and D3 is 0.24, and the expertise diversity in discussion threads D2 and D4 is 0.73.The expertise diversity of the surveyed discussion threads ranged from 0 to 0.86 in this study.

Cross-Network Common Experience

To measure this construct, I adopted Bunderson and Sutcliffe's (2002) index of intrapersonal functional diversity (a team-level construct), which was originally designed to measure the aggregate functional breadth of team members based on the history of their functional backgrounds. Simply speaking, the index of intrapersonal functional diversity is 0 when the team is full of narrow specialists with experience in one or two functional areas and is close to 1 when the team is full of broad specialists with experience in a range of functional areas.

I adapted this index to measure instead the discussion participants' cross-network common experience. By limiting the scope of expertise domains with which one is familiar to the set of main expertise domains ("home" communities) represented by the discussion participants in a given discussion thread, I ensured that there was a higher level of cross-network common experience among discussion participants when they were broad generalists (after controlling for the number of participants and expertise diversity among others)—this was because broad generalists would have more overlaps in community membership. In short, cross-network common experience was measured by the aggregate breadth of discussion participants' *regular participations* in the virtual communities *related to* the given discussion.

The operationalization of this construct warrants two clarifications. First, one's *regular participation* in a community (i.e., indicated by "v" in Figure 4) was determined by two conditions: membership and readership. In order for one to be considered as having participated regularly in a community, one has to be not only an official member of the community but also demonstrate that one frequently and consistently has visited the community website (being a member of a community does not necessarily mean that one has actually participated in the community). The Knowledge Sharing Group came up with a readership index that ranged from 1 to 5 with 1 indicating a rare and random visit pattern and 5 indicating a daily visit pattern. The readership index was regularly generated based on 6 month-data. I believe an individual-level readership index is a more accurate indicator of an individual's semantic and syntactic understanding of the domain of respective community. Second, *virtual communities related to the given discussion* are the "home" communities represented by the discussion participants in the given discussion. In the case of D2 in Figure 4, the communities related to the discussion represent four domains – A, B, C, and D only (there are four distinct home communities from which discussion participants come). Remember that cross-network common experience refers to the overlap of the discussion participants' semantic and syntactic understanding of the represented domains. Advice Provider 2 may also be a regular member of community specialized in domain E. In this case, I assume that Advice Provider 2's understanding of domain E is irrelevant to the given discussion because none of the participants claims E as his/her main expertise domain (home community).

The within-thread discussion participants' cross-network common experience was calculated as follows:

$$\sum_{i=1}^{m}(1 - \sum_{j=1}^{n} {p_{ij}}^2)/\mathrm{m},$$

where p_{ij} is the proportion of discussion participant i's total years of participation spent at the j_{th} virtual community; m equals the number of discussion participants in the discussion; and n is the total number of specialization categories, or "home" communities, represented in the discussion (n ranged from 1 to 5 in this study). Similar to expertise diversity, the index of cross-network common experience falls in between 0 (narrow) and 1 (broad). A higher index score indicates that the discussion thread is more composed of broad generalists as opposed to narrow specialists. The within-thread cross-network common experience index is minimized when everyone has participated only in his or her home community and is maximized when everyone has also participated in all the other participants' "home" communities. For instance, in Figure 4, suppose that everyone has participated in their virtual communities for 3 years. The indexes of discussion threads D1, D3, D2, and D4 are then 0.00, 0.07, 0.43, and 0.69, respectively. The index of cross-network common experience in this study ranged from 0 to 0.75.

Collective Elaboration

To measure "collective elaboration", I developed a coding scheme consisting of seven items. I decided to create a coding scheme for my study because there were no established measures of elaboration that would perfectly capture the gist of collective elaboration. Researchers have developed measures of group-level elaboration in various ways to reflect the specific contexts of their studies, using different methods such as survey, content analysis, and experiment (Zhong and Majchrzak 2004; Majchrzak et al. 2005; Homan et al. 2007; 2008; Kearney et al 2009). None of the existing measures of elaboration was, however, suitable for measuring the collective elaboration construct used in this study (see Appendix VI: Measures of Elaboration)

Table 4 Coding Scheme for Collective Elaboration

Coding item	Operationalization	Example
Asking for clarification	Whether the participant asks others to clarify their advice (including information, assumptions, perspectives, and/or approaches) [0,1]	"Scott, could you clarify why Company X proposes to use Y in place of…?"
Validating others' advice	Whether the participant validates others' advice by providing supporting fact or sharing related experience [0,1]	"My experience is exactly aligned with what Bob has suggested in that…"
Extending others' advice	Whether the participant builds upon others' advice by adding something new to extend the given advice (not just agreeing) [0,1]	"Along the same line, I'd also like to add that…"
Challenging others' advice	Whether the participant disagrees or challenges others' advice [0,1]	"Be careful with… My experience has been that…"
Conditioning others' advice	Whether the participant refers to others' advice by clarifying hidden assumptions or boundary conditions [0,1]	"I agree with Clive … unless you are… , but otherwise…"
Clarifying one's advice	Whether the participant answers questions or elaborates on the reasoning behind his or her advice [0, 1]	"The reason I say this is that…"
Combining others' advice	Whether the participant combines different pieces of advice by identifying relationships among them [0,1]	"All comments given so far are all good. Let me summarize them by…"

The coding items reflect seven representative collective elaboration instances (see Table 4). The coding scheme was developed through an iterative process of refinement. I first drafted a coding scheme based on previous elaboration studies. Through a preliminary analysis of randomly selected discussion threads, which were not part of this study, I continued to revise and refine the coding scheme until I reached saturation. I then sought feedback on the coding scheme from my interviewees and modified and refined the coding scheme. For instance, the coding item "clarifying one's advice" was newly added to the list because interviewees explained that "clarifying one's advice" could help others to relate to their advice more easily when the underlying *reasoning* of one's advice was explicitly elaborated.

Each message in the sample threads was coded either 0 or 1 for each item by two raters, me and another graduate student. Message-level scores were summed up to the thread level. Kudaravalli and Faraj (2008) employed this rating approach in their content analysis of communicative interactions in online discussion forums (See Appendix VII: Collective Elaboration Coding Sample).

Inter-rater reliability was tested to assess how closely the two coders agreed on the coding scheme and used it in a consistent manner. Following Miles and Huberman (1994), the two coders were trained with the definition of collective elaboration and the process of coding in a consistent manner. A common set of discussion threads (which were not part of the analysis for this study) was given to the two raters for a coding exercise. Inter-rater agreement was checked and a debriefing for re-training followed a few times until both coders felt confident about being on the same page. Then, following Dahlin et al. (2005), about 10% of the total discussion threads—20 discussions—were randomly chosen to test inter-rater reliability. The two raters worked on the same set of 20 discussion threads. Both of them were blind to the expertise diversity, learning, and performance scores of the discussion threads they were coding. Inter-rater agreement was measured as the number of agreements divided by the total number of observations per discussion thread. The inter-rater reliability was high; Cohen's kappa (per discussion thread) varied between 0.71 and 0.87, indicating good to excellent agreements (Fleiss 1981). The acceptable cutoff is 0.70 (e.g., Dahlin et al. 2005; Robert et al. 2008). After high inter-rater reliability was reached, the two coders divided their work and completed coding the remaining discussion threads. The score of collective elaboration in this study ranged from 0 to 14.

The Advice Seeker's (Team) Learning

Knowledge management studies indicate that the knowledge seeker is the best, perhaps the only, judge of the usefulness of knowledge received from a particular source (Levin and Cross 2004; Constant et al. 1996; Ko et al. 2005; Majchrzak et al. 2005). Accordingly, in this study, I used the survey to capture the advice seeker's evaluation, as an informant for his/her team, of team learning from the discussion thread and performance.

The advice seeker's team learning was measured using six survey items adapted from Vandenbosch and Higgins (1996), whose learning measures have been successfully used in previous IS research (e.g. Majchrzak et al. 2005). The items are meant to measure perceived changes in the seeking team's initial understanding of the problem the seeker asked about. The items asked in the survey are shown in Table 5.

The Advice Seeker's (Team) Performance Outcomes

Because it is difficult to quantify the change in the advice seeking team's performance as a result of the respective discussion, I measured performance via five survey items representing knowledge application toward specific ends. The advice seeking team performance was strictly related to the tangible outcomes of the discussion thread – I believe this is a better measure than general team performance because performance is affected by so many other things I could not possibly control for. The measure was based on the seeker's ratings of the tangible outcomes of the discussion thread suggested by managers of the field site, some of which can also be found in the decision making and problem solving literature (Dooley and Fryxell 1999; Sheremata 2000; Atuahene-Gima 2003). The three established criteria were problem solving speed, solution quality, and decision quality, and the two other criteria added anew were business value creation and mistake avoidance (see Table 5).

Control Variables

Several control variables were included to rule out alternative explanations for the hypothesized relationships.

Offline communication

This dissertation focuses on advice seeking and providing occurring in online discussion threads only. I controlled for offline communication because of the possibility that some advice seeking teams might have followed up with one or more advice providers outside the discussion threads for further offline advice seeking via phone, face-to-face meeting, email, or instant messaging (thus not captured in the threads). I included a question in the survey asking if there was any offline follow-up advice seeking. Discussion threads whose advice seekers reported that they had offline communication with any of the advice providers were rated 1 and all other threads were rated 0.

Discussion participation size

Discussion participation size was measured by the number of discussion participants. Following team diversity studies, I controlled for discussion participation size to capture the effects of expertise diversity over and above the effects of participation size.

The length of the discussion thread

For the same reason, I controlled for thread length, which was measured by the total word count of the discussion replies.

The length of discussion question

I controlled for the word count of the advice seeker's question to capture the possibility that a lengthy and detailed question might generate higher quality discussion (e.g. discussion participants might need to spend less time asking for clarification or misinterpret the question) while a short question might generate poor discussion.

Location diversity (country diversity)

Discussion participants from the same operation site, irrespective of their domain expertise, may have site-specific shared understanding not apparent to others from remote sites, thus hampering cross-site discussion (e.g. Tyre and von Hippel 1997; Cramton 2001; Sole and Edmondson 2002). To avoid this confounding effect, I controlled for location diversity based on the heterogeneity of countries in which discussion participants resided. Similar to expertise diversity, discussion participants' location diversity was computed using Blau (1977)'s index, ranging from 0 (low diversity) to 1 (high diversity). The location diversity of the surveyed discussion threads ranged from 0 to 0.84 in this study.

The advice seeking team's expertise levels

The level of expertise of the advice seeking team may affect how much they learn from the discussion thread. It may be that advice seeking teams already possess high levels of expertise and ask questions not to learn something radically new but to verify their knowledge or approach from other experts. In this case, they may rate their learning scores low irrespective of the quality of discussion. I controlled for the advice seeking team's expertise level based on three survey items adapted from Levin and Cross (2004). Because the items were originally developed for a dyadic relation, I slightly changed the wording of the items to fit them to this study's context (see Table 5).

The advice seeker's personal satisfaction with the electronic advice network (discussion forum)

To ensure that survey respondents were not simply answering questions on the basis of their *personal* attitude toward electronic advice network, I included a control variable to capture their overall satisfaction with the advice network as a platform from which to seek and gain technical advice. A bias might arise if an underlying satisfaction or dissatisfaction with the advice network affected responses to the questions about how the online discussion contributed to their team learning and performance.

The advice seeker's discussion participation

I controlled for the possible effect of the advice seeker's discussion participation as it could influence the level of the providers' collective elaboration, the seeker's team learning and performance. A discussion thread was rated 1 if the advice seeker (or any other member(s) from the seeker's team) participated in discussion by asking or answering questions. A discussion thread was rated 0 if the advice seeker (and his/her team members) initiated a discussion but did not further participate in the discussion thread. In all, 31 out of 190 discussion threads were rated 1.

Resource unavailability

I included a control variable related to the advice seeking team's resource constraints. Irrespective of collective elaboration and learning, the advice seeking team may not perform as intended if suffering from resource constraints. For instance, an advice seeker's team might have learned a great deal from a discussion thread, but had to report that the discussion thread did not help the team to perform better (e.g., manage time better, create business value) because the related project got canceled or delayed due to budget constraints. I thus added an open-ended question in the survey to control for this type of resource constraint circumstances that had little to do with the discussion thread itself.

CONSTRUCT VALIDITIES AND RELIABILITIES

I tested the construct validities (discriminant and convergent validities) and reliability (internal consistency) of the multi-item constructs used in my model.

Validities

Discriminant validity was checked using exploratory factor analysis. Discriminant validity indicates the extent to which a given construct is different from other constructs. The measures of all constructs should be distinct and the indicators should load on the appropriate construct. Factor analysis was used to identify any items that cross-loaded on other constructs. One learning item (Learning5) cross-loaded almost equally on the performance construct, thus was dropped. After trimming of the item, the results in Table 5 show that all items are loaded on their intended constructs above .70.

Convergent validity was demonstrated by showing that items for constructs correlate with each other to an acceptable degree, particularly when compared to the convergence of items relevant to other constructs. Item-to-total correlation was evaluated for each item to check the convergent validity of the multi-item constructs. This approach assumes that the extent to which the item correlates with the total sum of the remaining items belonging to the same construct is indicative of convergent validity for the item. Table 5 shows that the item-to-total correlation score varies from .62 to .81, all above .40, indicating that all items converge cleanly on their intended constructs.

Table 5 Factor Loadings [a] and Survey Items

Rotated Component Matrix[a]	Component (Construct) Performance	Learning	Expertise Level	Item-to-total correlation	Survey Item
					Q: To what extent did the discussion on your post help your team to... ? [b]
Performance1	**0.7**	0.23	-0.02	.62***	Manage time effectively
Performance2	**0.76**	0.34	-0.09	.74***	Create business value for your unit (such as issue resolution, LPO reduction, cost savings, risk reduction of HSE events, etc.)
Performance3	**0.82**	0.31	-0.13	.80***	Do a good job of meeting your unit's needs
Performance4	**0.85**	0.21	-0.05	.77***	Make a decision based on the best available information
Performance5	**0.77**	0.22	.-04	.68***	Avoid making mistakes that would harm the business
					Q: To what extent did the discussion on your post enable your team to do the followings (with respect to the topic of your post)?[b]
Learning1	0.42	**0.7**	-0.22	.76***	Expand your team's scope of thinking about the topic.
Learning2	0.22	**0.83**	-0.23	.79***	Challenge your team's perspective on the topic.
Learning3	0.24	**0.77**	-0.17	.69***	Question your team's initial assumptions about the topic.
Learning4	0.31	**0.78**	-0.17	.78***	Rethink about the topic in a new or different way.
Learning6	0.4	**0.67**	-0.21	.73***	Broaden your team's outlook about the topic.
					Q: "Prior to" seeking advice from the discussion forum "Ask & Discuss,"our team had...[c]
ExpLv1	-0.08	-0.14	**0.9**	.78***	Full understanding of the topic of my post.
ExpLv2	-0.07	-0.21	**0.89**	.80***	Adequate expertise to feel comfortable with the topic of my post.
ExpLv3	-0.05	-0.26	**0.86**	.81***	Confidence to perform successfully all the activities related to the topic of my post.

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.
b. The trimmed Learning 5 item concerned “Improve your team's insight into the topic”
   5 Likert-scale: (No extent – Great extent)
c. 5 Likert-scale: (Strongly disagree – Strongly agree) *** $p < .001$.

Reliabilities

In addition to construct validity ("an issue of measurement *between* constructs"), it is necessary to test reliability ("an issue of measurement *within* a construct") (Straub et al. 2004). I ran a reliability test to assess the consistency of the measurements of constructs. Cronbach's alpha value of the three constructs above was measured to check the internal consistency reliability. As shown below in Table 6, Cronbach's alpha ranged from .88 to .90, all above .70, indicating high internal consistency.

Table 6 Internal Consistency of Multi-item Constructs

Construct	No. of Items	Cronbach's α (N = 190)
Learning	5	0.90
Performance	5	0.88
Expertise Level	3	0.90

In addition, I previously described that I assessed the inter-rater reliability of the measure of "collective elaboration," which was found to be reliable (high Cohen's kappa).

DATA ANALYSIS

I first conducted hierarchical (sequential) regression analyses to test the hypotheses in the research model. Given that the main interest of this dissertation lies in testing the significance of moderations, I believe hierarchical regression is the right statistical method as it allows terms to be added in a sequential manner, thus making an individual assessment of the significance of each term possible. Hierarchical regression has been widely used in the team diversity literature because many studies test interactions. Because the research model is a path model, I additionally conducted a partial least square (PLS) analysis to check the robustness of the findings from the hierarchical regression.

Assumption Checking

The following assumptions of multiple regressions were all met, assuring high reliabilities of the results of my analyses shown in Tables 8 and 9.

- *Linearity*

  Linearity was visually checked and confirmed by curve estimation and a residual plot.

- *Independence of errors*

  Independence of errors was checked by Durbin-Watson test. The scores were close to 2 (1.9 for Model 1, 2.1 for Model 2, and 2.0 for Model 3), an indication of a nearly perfect independence (Field 2009).

- *Homoscedasticity (homogeneity of variance)*

  Homoscedasticity was visually checked and confirmed by scatter plots of predicted values and residuals.

- *Multivariate and dependent normal distribution*

  Normality was tested and found by Shapiro-Wilk test. Also, Skewness and Kurtosis values were both less than 2 in all models, indicating no normality violation.

- *Multicollinearity*

Multicollinearity was of no concern because VIF scores were far less than 4 (ranging from 1.0 to 2.8 in all models) and Tolerance scores were bigger than .2 (ranging from .35 to .96 in all models), which are the cut-off points for multicollinearity.

Power

In advance of the study, I conducted Cohen's power analysis (1988) using Soper's "A-priori Sample Size for Multiple Regression" software available on http://www.danielsoper.com. Calculations were made based on an anticipated effect size of .15, an alpha of .05, 14 regression variables (3 independent variables, 1 interaction term, and 10 control variables), and a target power value of .85. The analysis estimated a sample size of 148 discussion threads (advice seekers) to be required for the regression analyses. Given that my final data pool was 190 discussion threads, the power analysis assured that I collected a large enough sample to proceed with the analyses.

A supplementary Test: PLS

In addition to sequential regression, I ran PLS analysis to check the robustness of the findings. The results of the PLS analysis corroborated those of sequential regression analysis. Please see Appendix VIII: PLS Analysis and Results for the detail. In Chapter 5, I will present the results of sequential regression analyses.

SUMMARY OF THIS CHAPTER

This chapter presented the collection and analysis of field data pertaining to this dissertation, including the field research site, data collection procedures, construct measures and the validities and reliabilities of the measures, power test, and analytical strategies. Data was collected from a global energy company well known for its successful running of electronic advice networks that span various virtual communities. A total of 190 discussion threads comprising 1,200 discussion participants (190 advice seekers and 1,110 advice providers) from 63 virtual communities were analyzed. The expertise diversity, collective elaboration, and cross-network common experience constructs were measured using the secondary data related to the discussion participants' virtual community memberships and activities, HR information, and discussion thread information. In particular, collective elaboration was measured based on a content analysis of the sample discussion threads. The advice seeker's team learning and performance outcomes resulting from the particular discussion triggered by the seeker's inquiry were measured via a survey. Validities and reliabilities of the constructs were tested and confirmed. I choose to test the hypothesized relationships via sequential regression analysis because the main interest of this dissertation lay in testing the significance of interactions. Power test confirmed that the sample size of 190 was large enough. To check the robustness of the findings, I choose to additionally run PLS regression analysis.

CHAPTER 5: RESULTS

In this chapter, I report the analytical techniques used and the results found, including the descriptive statistics for all the variables included in the research model and the results of the hierarchical regression analyses and the analyses of mediation and moderation effects.

MEANS, STANDARD DEVIATIONS, AND CORRELATIONS

Means, standards deviations, and Pearson correlations are presented in Table 7. Expertise diversity was not associated with collective elaboration, learning or performance, confirming that expertise diversity alone does not contribute to the advice seeking team's learning or performance. In addition, expertise diversity was positively associated with the number of discussion participants, suggesting that the more participants joined a discussion, the more diverse expertise domains they were likely to represent. Collective elaboration was positively associated with both learning and performance, and so was learning with performance. Expertise diversity was also positively correlated with discussion participants' cross-network participation. Given that the interactions of expertise diversity with these key constructs are of main interest in this dissertation, the interpretations of a correlation or a lack of correlation should be made in the context of the final results with respect to the particular interactions.

Table 7 Means, Standard Deviations, and Correlations

Variables	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Number of Participant	6.27	2.28														
2. Offline Communicati	0.46	0.50	0.10													
3. Country Diversity	0.48	0.23	0.31***	0.05												
4. Adv Skr's discussion	0.18	0.38	0.15*	0.19*	0.02											
5. Adv Gvrs' references	1.83	1.92	0.39**	0.03	0.07	-0.05										
6. Wordcount (Adv Skr's questio	117.04	84.92	0.22***	0.13	0.01	0.24**	-0.08									
7. Wordcount (discussion)	672.34	044.18	0.67***	0.16*	0.20**	0.28**	0.21**	0.32**								
8. Adv Skr's exp level	3.51	0.86	-0.05	-0.09	-0.02	-0.07	-0.02	0.07	-0.12							
9. Satisfaction	4.17	0.68	0.10	0.05	-0.02	0.03	0.05	0.01	0.12	-0.04						
10. Resource unavailabilit	0.09	0.29	-0.06	-0.02	-0.07	-0.02	-0.01	-0.08	-0.01	-0.01	0.02					
11. Expertise Diversity	0.48	0.20	0.10*	0.01	0.01	-0.02	0.01	-0.09	0.03	0.00	0.02	-0.16*				
12. Collective Elaboration	6.58	3.46	0.55**	0.20***	0.17*	0.11	0.22**	0.15*	0.36**	-0.19	0.29**	-0.11	0.09			
13. Cross-netw com. experi	0.44	0.14	-0.16*	-0.03	-0.02	-0.01	-0.01	0.15*	-0.04	-0.04	-0.06	0.02	0.50**	-0.07		
14. Learning	2.88	0.87	0.16*	0.25***	0.08	0.15*	-0.03	0.13	0.20**	-0.42*	0.33**	0.15*	-0.05	0.53**	-0.02	
15. Performance	2.88	0.94	0.21**	0.20***	0.08	0.13	0.09	0.13	0.15*	-0.16*	0.39**	-0.25*	0.09	0.66**	0.05	0.66*

Note. N=190 discussion threads (advice seekers). * p < .05, ** p < .01, & *** p < .001 (all 2-tailed).

RESULTS OF THE HIERARCHICAL REGRESSION ANALYSES

Table 8 and Table 9 present the results of the hierarchical regression analysis. Expertise diversity, collective elaboration, and cross-network common experience were mean-centered before interaction terms were constructed and tested to avoid multicollinearity. The primary purpose of the analyses was to examine whether the variance of a dependent variable was significantly explained by the interaction of main effects after the variance explained by both controls and main effects was accounted for. In each model (Models 1, 2, and 3), controls, main effects, and the interaction term were entered in a sequential manner.

Interaction of Expertise Diversity and Collective Elaboration

In Model 1, learning was regressed on the variables, as shown in Table 8, which were entered in 3 steps. I entered the control variables in the first step, expertise diversity and collective elaboration in the second step, and the interaction of expertise diversity and collective elaboration in the third step. Two controls were found significant. The expertise level of the advice seeking team was found to be negatively associated with their learning from the discussion thread. Given that there was no negative relationship found between the expertise level of the advice seeking team and performance (later in Model 2), one can infer that advice seeking teams with high levels of expertise are less likely to learn something new from discussions and yet may find them to be helpful for improving their performance. For example, teams that have good ideas about how to handle their problems may just want to verify from others that they are on the right track. In this case, they may not find the discussion to be eye-opening but still find it to be helpful in meeting their needs. In addition, the advice seeker's personal satisfaction with the electronic advice network as a platform to seek and gain advice was found to be positively associated with learning. Expertise diversity alone was not found to be significantly related to learning whereas collective elaboration was. The strong and persistent effect of collective elaboration suggests that collective elaboration is far more important than expertise diversity.

Hypothesis 1 states that expertise diversity interacts with collective elaboration in predicting the advice seeking team learning, such that there is a positive relationship between expertise diversity and learning when the level of collective elaboration is high and a negative relationship when the level of collective elaboration is low. According to Model 1 (Step 3) in Table 8, after the variance explained by both controls and main effects was accounted for, the interaction of expertise diversity and collective elaboration explained a significant amount of variance, thus indicating a significant moderation effect ($\Delta R^2 = .02$, $\beta = .15$, $t = 2.24$, $p < .05$).

Table 8 Results of the Regression Analysis for Hypotheses 1 and 2

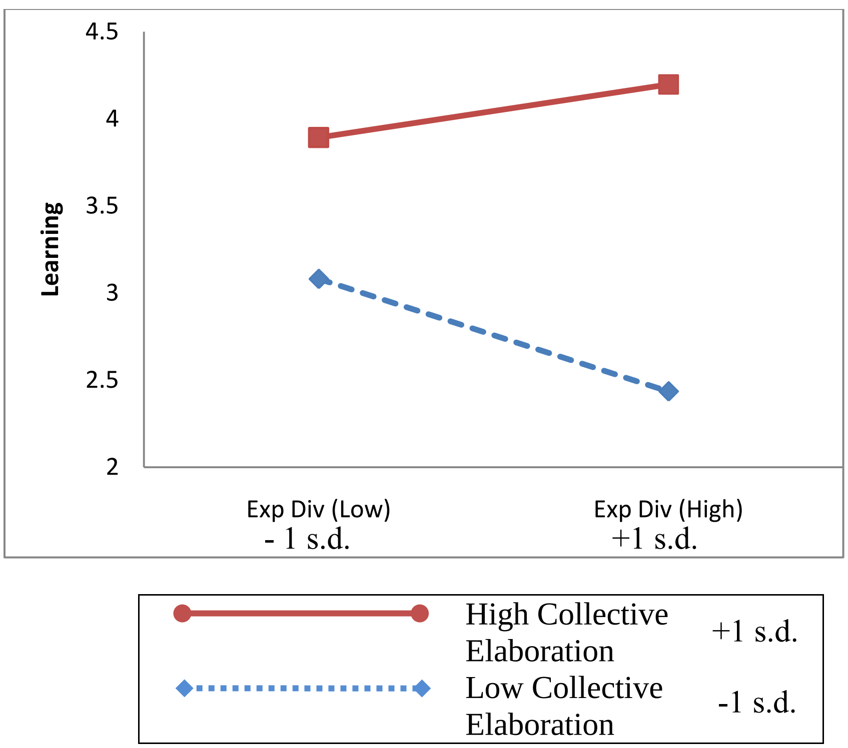
	Model 1: Learning			Model 2: Performance			
Independent Variables	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3	Step 4
Step 1: Controls							
Number of participants	.04	-.07	-.07	.06*	-.10**	-.10**	-.06
Offline communication	.28*	.18	.19	.25*	.09	.09	-.04
Country diversity	.21	.18	.16	.12	.11	.08	-.03
Advice seeker's discussion participation	.11	.11	.12	.16	.16	.18	.11
Advice givers' references	-.04	-.04	-.04	.02	.02	.02	.04
Word count (advice seeker's question)	.00	.00	.00	.00	.00	.00	.00
Word count (discussion)	.00	.00	.00	.00	.00	.00	.00
Advice seeker's expertise level	-.40***	-.35***	-.35***	-.15*	-.08	-.08	.10
Satisfaction (with the advice network)	.38***	.23**	.22**	.51***	.28***	.28***	.18**
Resource unavailability				-.79***	-.59***	-.64***	-.89***
Step 2: Main effects							
Expertise diversity		-.39	-.34		.10	.15	.23
Collective elaboration		.12***	.12***		.18***	.18***	.11***
Step 3: Interaction							
Expertise diversity * collective elaboration			.15*			.14*	.08
Step 4: Mediator							
Learning							.56***
R^2	.35	.49	.50	.30	.54	.52	.66
ΔR^2	.35***	.14***	.02*	.30***	.24***	.01*	.13***
F	12.22***	17.09***	16.38***	8.51**	19.03***	18.17***	29.15***

Note. N=190 discussion threads. Unstandardized regression coefficients and unadjusted R^2 values are reported. To avoid multicollinearity, means were centered before interaction terms were constructed and tested. * p < .05, ** p < .01, and *** p < .001 (all 2-tailed).

To further explore this result, I used Aiken and West (1991) procedures to plot the interaction between expertise diversity and collective elaboration. The regression equation had standardized predictors (expertise diversity and collective elaboration), the interaction term, and standardized control variables. I calculated values for high (+1 s.d.)

and low (-1 s.d.) expertise diversity as a function of high (+1 s.d.) and low (-1 s.d.) values on the moderator, collective elaboration, to plot the two-way interaction. This yielded a plot of the advice seeking team's learning at low vs. high levels of expertise diversity and collective elaboration. The plot (Figure 8) shows a positive effect of discussion participants' expertise diversity on the advice seeking team's learning when the level of collective elaboration was high and a negative effect when the level of collective elaboration was low.

Figure 8 Relationship between Expertise Diversity, Collective Elaboration, and Learning



As a supplementary test, I ran a simple slope test (Aiken & West 1991) to see whether the slopes in Figure 8 were significantly different from 0. This test showed that for discussion threads with low collective elaboration, there was a significant negative relationship between expertise diversity and learning ($\beta = -.86$, $t = 0.25$, $p < .001$). By contrast, for discussion threads with high collective elaboration, there was a positive but insignificant relationship between expertise diversity and learning ($\beta = .17$, $t = 0.64$, $p =$ n.s.). Overall, without collective elaboration, expertise diversity can be problematic. Given that the relationship between expertise diversity and learning was contingent on the level of collective elaboration, particularly when the level of collective elaboration was low, I found support for Hypothesis 1.

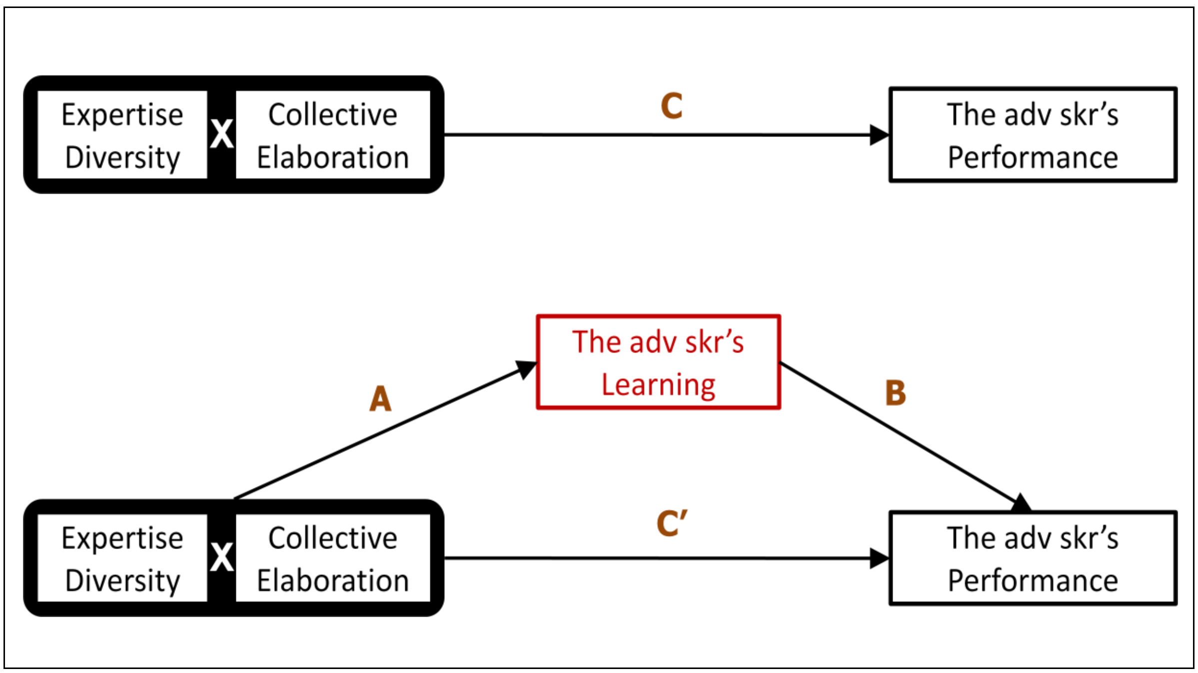
The Mediating Role of Learning

Hypothesis 2 states that expertise diversity interacts with collective elaboration in predicting the advice seeking team performance outcomes through the advice seeking team's learning. In other words, the advice seeking team's learning mediates the moderated effect of expertise diversity on the advice seeking team's performance.

In Model 2, the advice seeking team performance was regressed on the variables, as shown in Table 8, which were entered sequentially in four steps. Learning was entered into the model in the last step to test the mediating role of learning. As for controls, resource unavailability was newly added to the model. Two controls, the advice seeker's personal satisfaction with the electronic advice network and resource unavailability, were significantly associated with performance. As previously reasoned, external events causing related resources to be unavailable were associated with negative ratings of team performance. Review of the respondents' comments revealed that teams that had to postpone or cancel their projects due to resource constraints reported low ratings (i.e., no practical benefits from the discussion) no matter how much they learned from the discussion.

As for the main effects, similar to Model 1, expertise diversity alone was not found to be significantly related to performance outcomes whereas collective elaboration was, reaffirming the strong and persistent effect of collective elaboration on performance.

Figure 9 Mediated Moderation of Learning



Note. A, B, C, C' refer to paths that can be estimated by regression.

To assess the moderated mediation effect of learning, I employed two tests: Baron and Kenny (1986)'s test, the most commonly and frequently cited test of mediation in psychometrics, and the Sobel test (MacKinnon, Warsi, and Dwyer 1995) as a supplementary test. These two tests have been widely used by team diversity studies testing mediated moderation (e.g., Van der Vegt and Bunderson, 2005; Homan, Hollenbeck, Humphrey, Knippenberg, Ilgen, and Van Kleef, 2008).

The two diagrams in Figure 9 are useful for understanding the purposes of these two tests. In essence, Baron and Kenny's test examines whether the moderation effect of collective elaboration on the relationship between expertise diversity and the advice seeking team's performance outcomes no longer exists after learning is controlled. If the path between expertise diversity * collective elaboration and the advice seeking team's performance outcomes changes from significant to insignificant (i.e., statistically significant C turning into insignificant C') once learning is added to the model, learning is believed to be fully mediating. The Sobel test further examines the significance of the mediation of learning by examining whether the indirect effect of learning (AB) is significantly different from 0; that is, whether there is a significant difference between the total effect (C) and the direct effect (C`).[6]

Adopting Kenny (2009)'s description of the four steps in inferring mediation, I conducted Baron and Kenny's test to see if the following requirements were met:

1. Expertise diversity * Collective elaboration predicts Performance (C)
2. Expertise diversity * Collective elaboration predicts Learning (A)

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[6]Many studies use bootstrapping as the preferred method over Sobel test. This is not because Sobel test is an old technique but because Sobel test assumes normality whereas Bootstrapping overcomes the statistical limitation (normality assumption). Given that my research model meets the assumption of normality, both tests produce more or less similar results.

3. Learning predicts Performance (while controlling for Expertise diversity * Collective elaboration) (B)
4. Expertise diversity * Collective elaboration does NOT predict Performance (while controlling for Learning) (C`)

The results, as shown in Table 8, indicate that the requirements are all met, supporting Hypotheses 2. The first requirement is met, as is evident in step 3 of Model 2. After control variables (step 1) and the main effects (step 2) were entered, the interaction of expertise diversity and collective elaboration was added (step 3) and found to be significant (C: $\beta = .14$, $t = 2.22$, $p < .05$). The second requirement is met by the empirical support for Hypothesis 1 (A). The third and fourth requirements are met as evident in step 4. Once learning was finally added to the model as a mediator, learning was found to be significant in contributing to performance (B: $\beta = .56$, $t = 8.78$, $p < .001$) while the significance of the interaction term (expertise diversity * collective elaboration) disappeared (C`: $\beta = .08$, $t = 1.45$, $p=.15$). In addition, the Sobel test proved that there was a significant difference between the total effect (C) and the direct effect (C`), further indicating the significant moderated mediation effect of learning ($Z= 2.15$, $P < .05$)[7].

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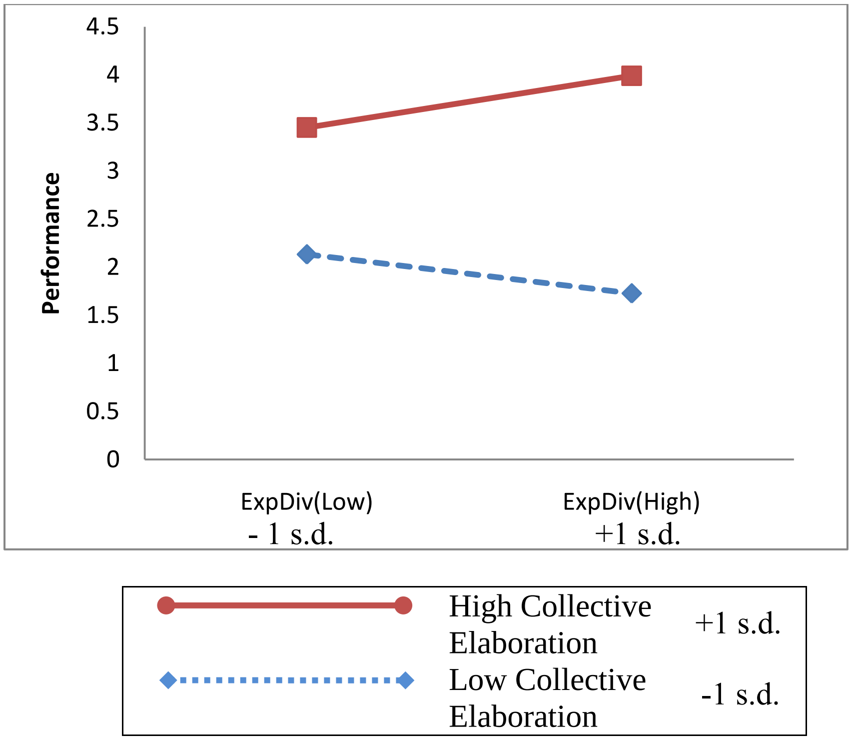
[7] The mediated effect was calculated by Preacher and Leonardelli's Sobel test calculation tool. The tool is available at http://www.people.ku.edu/~preacher/sobel/sobel.htm, as of November 12, 2010.

Figure 10 Relationship between Expertise Diversity, Collective Elaboration, and Performance



Similar to Figure 8, the plot above (Figure 10) shows a positive effect of discussion participants' expertise diversity on the advice seeking team's performance when the level of collective elaboration was high and a negative effect when the level of collective elaboration was low. Simple slope test showed that for discussion threads with low collective elaboration, there was a nearly significant negative relationship between expertise diversity and performance ($\beta = -.86$, $t = 1.73$, $p < .10$). By contrast, for discussion threads with high collective elaboration, there was a significantly positive relationship between expertise diversity and performance ($\beta = 1.06$, $t = 2.03$, $p < .05$).

This two-way interaction existed due to learning—once learning was entered into the model, this interaction no longer existed.

The results above confirm that the advice seeking team's learning fully mediates the effects of the interaction between expertise diversity and collective elaboration on the team's performance. Hypothesis 2 is thus supported.

Interaction of Discussion Participants' Cross-Network common experience and Collective Elaboration

Hypothesis 3 states that cross-network common experience moderates the relationship between expertise diversity and collective elaboration such that there is a positive relationship between expertise diversity and collective elaboration when the discussion participants' cross-network common experience is broad and a negative relationship when it is narrow.

In Model 3, as shown in Table 9, control variables (step 1) and the main effects of expertise diversity and discussion participants' cross-network common experience (step 2) were entered first. Neither expertise diversity nor discussion participants' cross-network common experience alone predicted collective elaboration. As hypothesized, the interaction of expertise diversity and discussion participants' cross-network common experience explained a significant amount of variance of collective elaboration (step 3), indicating a significant moderation effect ($\Delta R^2 = .03$, $\beta = .18$, $t = 2.83$, $p < .01$).

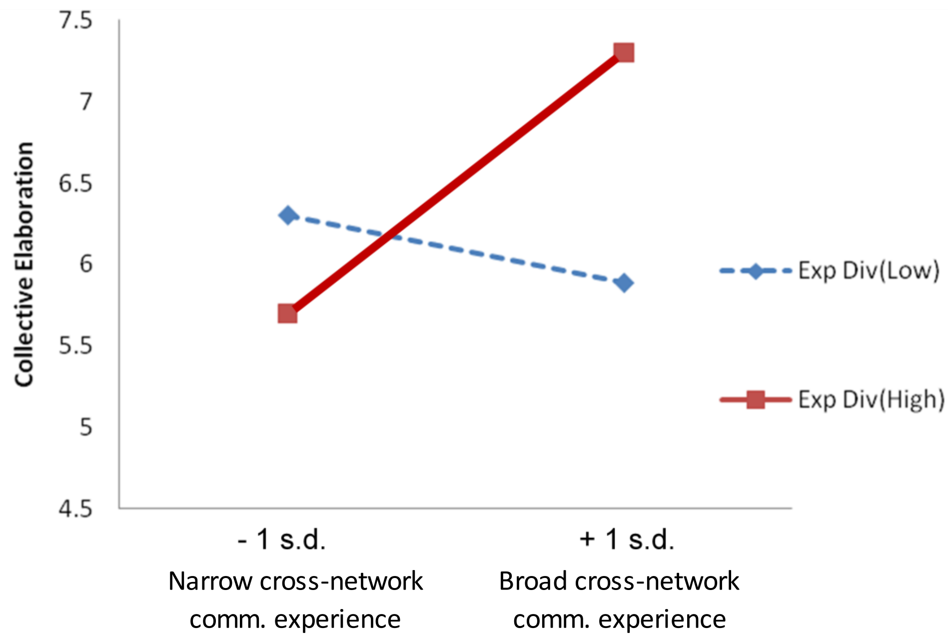
Table 9 Results of the Regression Analysis for Hypothesis 3

Independent Variables	Model 3: Collective Elaboration		
	Step 1	Step 2	Step 3
Step 1: Controls			
Number of participants	.92***	.92***	.90***
Offline communication	.86*	.85*	.98*
Country diversity	-.20	-.16	.04
Advice seeker's discussion participation	.02	.02	-.07
Advice givers' references	.00	.00	-.03
Word count (advice seeker's question)	.00	.00	.00
Word count (discussion)	.00	.00	.00
Step 2: Main effects			
Cross-network common experience		.41	.30
Expertise diversity		.59	1.25
Step 3: Interaction			
Cross-network comm. experience * Expertise diversity			18.02**
R^2	.35	.36	.38
ΔR^2	.36***	.00	.03**
F	12.34***	9.85***	10.04***

Note. N=190 discussion threads. Unstandardized regression coefficients and unadjusted R^2 values are reported. To avoid multicollinearity, means were centered before interaction terms were constructed and tested. * p < .05, ** p < .01, and *** p < .001 (all 2-tailed).

To further explore this result, I plotted the interactive effect of expertise diversity and cross-network common experience on collective elaboration. I illustrated the relationships between expertise diversity and collective elaboration based on narrow vs. broad cross-network common experience. Figure 11 highlights that the effect of discussion participants' cross-network common experience on collective elaboration is particularly striking in discussion threads with high levels of expertise diversity. The level of collective elaboration was low or high, depending on the aggregate breadth of discussion participants' cross-network common experience.

Figure 11 Relationships among Expertise Diversity, Discussion Participants' Cross-network Common experience, and Collective Elaboration



Simple slope tests revealed that for discussion threads with high levels of expertise diversity, there was a significant positive relationship between discussion participants' cross-network common experience and collective elaboration ($\beta = 4.72$, $t = 2.14$, $p < .005$). In other words, in high expertise diversity discussion threads, the levels of collective elaboration were significantly associated with the breadth of discussion participants' cross-network common experience – when the discussion participants' cross-network common experience was broad (narrow), they engaged in high (low) levels of collective elaboration.

In contrast, for discussion threads with low levels of expertise diversity, there was no significant relationship between discussion participants' cross-network common experience and collective elaboration ($\beta = -3.65$, $t = 1.62$, $p =$ n.s.). In other words, in low expertise diversity discussion threads, discussion participants' cross-network common experience did not significantly determine the levels of collective elaboration because their common experience was limited to few domains anyway. The additional PLS regression analysis corroborated these findings, confirming the robustness of the findings (See Appendix VIII: PLS Analysis and Results). Taken together, the results support Hypothesis 3.

SUMMARY OF THIS CHAPTER

This chapter presented the results of the hypothesis testing via tables and graphical representations of interactions. The hypothesized relationships were all supported. The relationships between expertise diversity and the advice seeking team's learning and performance were found to be moderated by collective elaboration. In the absence of collective elaboration, expertise diversity was problematic for the advice seeker and his/her team. The advice seeker's team learning was found to mediate the interactive effect of expertise diversity and collective elaboration on team performance.

Discussion participants’ cross-network common experience was significantly related to collective elaboration when expertise diversity was high.

CHAPTER 6: DISCUSSION

In this chapter, I discuss the results presented in Chapter 5 and the theoretical and practical implications of the results. I also address the limitations and future directions of this dissertation.

Guided by the information processing view of the team diversity research, virtual community researchers have assumed and rarely questioned the performance potential of expertise diversity. The inconsistency between the theoretical rationale supporting the positive effects of expertise diversity on the advice seeker's learning and performance and the empirical evidence that finds no or negative relationships of the two has pointed to a gap in our academic understanding. Recognizing the substantial gap in our understanding of how to best harness the performance potential of expertise diversity provided through an electronic advice network within a firm, this dissertation explored the following question: how and under what conditions would the expertise diversity manifested in an electronic advice network promote or fail to promote the advice seeker's team learning and performance outcomes? Drawing from the literatures on elaboration, knowledge boundaries, and communities of practice, I specifically focused on when and how the difference and relevance, and novelty of domain-specific knowledge are communicated and come to be understood through discussion participants' communicative interactions. This dissertation unearthed the relationships between expertise diversity and the advice seeker's team learning and performance in an electronic advice network by identifying the mediating roles of collective elaboration and cross-network common experience.

SUMMARY OF THE FINDINGS

In contrast to the domain view in the virtual communities literature that the advice seeker will benefit from an electronic advice network that provides diverse, non-redundant informational inputs, I found that discussion participants' expertise diversity did not predict the advice seeker's team learning or performance (nor did the number of discussion participants). The relationship between the diversity of expertise held by discussion participants and the advice seeker's (team) learning and performance outcomes resulted from the discussion was positive in some cases and negative in others. During the debriefing of the survey, I found that there were as many advice seeking teams who reported negative discussion experience as those who reported positive experience with highly diverse discussion threads.

> *"The advice helped my team to make an informed decision and allowed us to mitigate risk and maximize value… The discussion group provided good comparison and alternate ways of thinking."*

> *"Honesetly, we were disappointed; the replies ranged from irrelevant to contrary… Some gave good comments, but not much specific information on how they were inter-related."*

From my analysis of the 190 surveyed discussion threads, I identified the significant role of collective elaboration in realizing the performance potential of expertise diversity in an electronic advice network; what determined the nature of the relationship was the presence vs. absence of collective elaboration. When discussion participants with diverse expertise engaged in collective elaboration, the advice seeker (and his/her team) was able to learn significantly and enjoy task-related tangible outcomes. In contrast, the absence of collective elaboration was found detrimental to the relationship between expertise diversity and the advice seeker's (team) learning and performance in that the advice seeker (and his/her team) learned less and benefited less in the absence of collective elaboration, the more diverse the advice they had received through an electronic advice network. A simple slope test revealed that, in the absence of collective elaboration, advice seekers actually achieved significantly higher learning and performance outcomes (though at moderate levels) from homogenous discussion groups (i.e., low expertise diversity discussion threads) than from heterogeneous discussion groups (i.e., high expertise diversity discussion threads). The findings of this research suggest that, without collective elaboration, expertise diversity can be problematic.

As has been assumed in the literature, learning was also found to play an important role in realizing the performance potential of expertise diversity by mediating the interactive effect of collective elaboration and expertise diversity on the advice seeker's team performance. Also, in my interviews, I learned that the discussion thread triggered by an inquiry posed by an advice seeker was a key activator of the seeker's team discussion through which the team often achieved a great deal of learning particularly when the discussion thread contained new knowledge inputs that were clearly communicated. Combined with the finding of the mediating role of collective elaboration, these findings suggest that one key means by which expertise diversity in an electronic advice network produces tangible outcomes for the advice seeker's team is by stimulating the restructuring of the team's cognitive model to adapt to collectively elaborated new knowledge.

In addition, the results of this research help to explain the condition under which discussion participants are able to engage in collective elaboration. As predicted, discussion participants were not always able to engage in collective elaboration, particularly in high expertise diversity discussion threads, due to a lack of shared syntactic and semantic understanding of each other's domain-specific knowledge. I found that the ability of the discussion participants to engage in collective elaboration was shaped by the participants' cross-network common experience; that is, discussion participants were unable to engage in collective elaboration when they had little cross-network common experience but able to engage in collective elaboration when they had broad cross-network common experience. Broad cross-network common experience enabled discussion participants with diverse expertise to engage in collective elaboration because their experience helped them to understand each other's language, meaning, and perspective.

In sum, the findings suggest that in order for an advice seeker to realize the performance potential of the diversity of knowledge shared through an electronic advice network, advice providers need to facilitate the advice seeker's learning by articulating the differences and relevance of their diverse knowledge, and this is only possible when they have previously developed shared syntactic and semantic understanding, for instance, through regular participation in each other's virtual communities.

LIMITATIONS AND FUTURE RESEARCH

I acknowledge several limitations to generalization in this study. The generalizability of the findings to other organizations may be limited, as I examined electronic advice networks from a single organization. The findings may not apply to organizations that provide no platform that helps communities to cross boundaries and allow their members to learn about and participate in discussion threads hosted in other virtual communities (e.g., no cross-posting allowed, membership required for viewing discussion threads). In addition, the findings may not apply to organizations that offer discussion forums to their employees but do not enable communities of practice, from which employees can learn domain-specific knowledge to broaden their cross-network common experience. Furthermore, while I argue that membership in the "home" (virtual) community is a good indicator of an individual's expertise domain, not every company running internal virtual communities organizes them around specific expertise domains.

In some organizations, certain communities may be organized around interests or topics that are not task or expertise-related.

I also identify several areas that offer future research opportunities. First, in some companies, the diversity of expertise may be much broader than the level of expertise diversity observed in this study. In this case, researchers may find non-linear, or curvilinear, effects of expertise diversity. Expertise diversity generally increases the complexity of group-level information processing (Van der Vegt and Bunderson 2005). Thus, beyond some point, members may not be able to utilize all the information and perspectives available to them. In highly expertise diverse discussions, if everyone brings in too many unique ideas and suggestions, it might be harder for discussion participants to engage in "focused" collective elaboration. In this case, the interactive effect of expertise diversity and collective elaboration on learning may be positive up to a certain point, but flatten out or turn negative (e.g., due to confusion) beyond that point. More research is needed to see if a similar pattern of results holds in different organizations, where different types or ranges of expertise diversity may exist, and how collective elaboration moderates the effects of diversity on learning and performance.

Second, while I controlled for offline communication, previous research has shown that knowledge seeking and sharing can be often a multi-phased and multi-channel process that occurs online and offline simultaneously (Teigland and Wasko 2003; Cross and Sproull 2004; Gray and Meister 2004; Olivera et al. 2006). In this study, 45% of the advice seekers (including members of their teams) were found to have communicated with one or more discussion participants offline, mainly to seek further clarification. However, there was no evidence that offline communication increased the advice seeker's team learning or performance. More research is needed to understand how the role of collective elaboration in team learning unfolds when advice seeking and providing occur in such a complex fashion.

Third, future research can explore the (moderating) role of the advice seeker in facilitating collective elaboration and, subsequently, enhancing learning. Many interviewees emphasized that asking a "good" question is an important element of successful discussion because it makes it easier for others to understand what the seeker is seeking and to stay focused on the topic. Previous research has revealed that how the seeker asks questions and the subsequent discussion is moderated is important for the success of online discussion (e.g., Ahern et al., 1992). In a study of three different mediator roles (question-only, statements-only, and conversational) in a computer-mediated discussion, Ahern and colleagues (1992) found that the conversational condition triggered larger participation and more complex interaction. They also found that discussion interactivity was higher when concrete questions were proposed. In this dissertation, the length of the advice seeker's inquiry was found to be positively related to the number of discussion participants (i.e., a detailed question enhances discussion participation). However, neither the seeker's inquiry nor the seeker's further participation in the discussion was found to enhance collective elaboration. Because only 16% of the surveyed advice seekers participated in their own discussion, it is not clear whether these non-supportive findings are due to a lack of power or something else. More research is needed to understand what consists of a “good” question and what type of moderating role the advice seeker should play to facilitate collective elaboration.

Finally, future research can explore more what enables or hinders not just the ability but also the motivation of discussion participants to engage in collective elaboration. This dissertation proposes one enabler of collective elaboration: discussion participants’ common ground—shaped by their cross-network common experience. In addition to the ability to engage in collective elaboration, discussion participants need a strong motivation to make an extra effort to build on previous advice or relate their advice to the advice provided by others in the discussion thread. While research on knowledge sharing in virtual communities has identified a whole range of factors that affect an individual’s motivation to share his/her knowledge, it is not clear whether the factors will also affect one’s motivation to engage in collective elaboration in the same manner. The costs and benefits associated with the act of sharing knowledge might be different from those of articulating one’s knowledge contribution in relation to other’s contribution. Research on team diversity often adopts team identity as a significant motivational driver of knowledge sharing in a diverse team (e.g., Van der Vegt and Bunderson), but it is not clear how one’s identity translates into one’s motivation in the context of an electronic advice network that spans multiple communities of practice. Future research can explore more in depth the motivational element of collective elaboration in an electronic advice network.

THEORETICAL IMPLICATIONS

The findings from this dissertation have several important theoretical implications for research.

Collective Elaboration in an Electronic Advice Network

Adopting the information processing perspective from the team diversity literature, virtual communities researchers have assumed that the advice seeker will benefit from the collective intelligence of advice providers with diverse expertise as long as the providers are motivated to share their knowledge. The findings of this dissertation suggest that this is not always true – the advice seeker will not benefit from diverse expertise unless providers engage in a specific group process termed collective elaboration. What should be noted is that collective elaboration is different from the group process assumed in the team diversity literature to mediate the effect of diversity on group performance. Team diversity research explains that the performance potential of expertise diversity is realized when individuals in the group share their unique domain-specific knowledge because expertise diversity is likely to stimulate an intensive collaborative group process in which differences in perspective, assumption, and/or approach are identified, negotiated, and resolved and knowledge relevant to the group's tasks is integrated. This dissertation argues that this type of group process may not be present in an electronic advice network due to the differences in the characteristics of an electronic advice network vs. a traditional (face-to-face) workgroup—discussion participants have little pressure to synthesize the differences in their advice to reach a consensus for the advice seeker not to mention their fluid participation makes it difficult to sustain a dialogue. In my content analysis of 190 online discussion threads, I found little evidence of knowledge integration through negotiation and consensus (but there was abundant evidence of collective elaboration moderating the relationship between expertise diversity and discussion outcomes). In online discussion forums, it is the advice seeker and his/her team, not the advice providers, who are responsible for processing and integrating the knowledge brought to the discussion. Thus, the group process that helps realize the performance potential of expertise diversity in an electronic advice network is a process that helps the advice seeker (and his/her team) to be able to process and integrate discussion participants' domain-specific knowledge. Collective elaboration was proposed and found to moderate the relationship between expertise diversity and discussion outcomes. Collective elaboration is not a mediator but a moderator of the two because the group process is emergent and voluntary – discussion participants engage in collective elaboration only when they are able (and motivated) to do so.

The moderating role of collective elaboration helps us to understand why previous virtual communities research may have found no relationship or even a negative relationship between expertise diversity and the advice seeker's learning and/or performance. For instance, the findings of this dissertation may explain why Constant and her colleagues (1996) found, in their study of an email listserv in an organization, that the (organizational position) diversity of advice providers did not predict the advice seeker's problem solving success and was even negatively related to the seeker's perceived usefulness of the overall advice. The results of this dissertation suggest that their findings might be explained by the absence of collective elaboration as it had the most negative consequences to the advice seeker's learning and performance when discussion participants' expertise diversity was high. In their study, advice seekers broadcasted their inquiries to the rest of the company and received individual replies to their inquires via email. Because the technology used in the organization did not allow the advice providers to participate in a "space" where they could see and grasp other's advice, share their own advice, and interact with each other, it was impossible for them to engage in collective elaboration. Due to the absence of collective elaboration, the advice seeker might have experienced a greater difficulty of processing and integrating replies the more diverse they were. In the case of Kudaravalli and Faraj (2008), they found that the diverse expertise of online discussion participants did not predict the success of the advice seeker's problem solving whereas the discussion participants' engagement in the discussion did (i.e., initiating dialogue and sustaining dialogue). The results of this dissertation provide a support for their findings and further suggest that when discussion participants exhibit both diverse expertise and active engagement in discussion—in the form of collective elaboration—, the likelihood of the advice seeker's problem solving success will be much higher.

In addition, this dissertation identifies an important condition under which discussion participants are able to engage in collective elaboration in the context of an electronic advice network. The finding that discussion participants' cross-network common experience shaped the level of the collective elaboration of the participants highlights the moderating role of common ground: *Previously developed* shared syntactic and semantic understanding is critical for enabling elaborated exchange of knowledge and perspectives in an electronic advice network. In the case of cross-functional workgroups, research has found that low common ground is typical when a workgroup is newly formed with members from different domains (i.e., a group composed of diverse narrow specialists), but the members are able to eventually engage in elaborated exchange of ideas and perspectives as they overcome their lack of shared syntactic and semantic understanding through rich and extensive interactions over time (Bechky 2003). The finding that discussion participants rarely engaged in collective elaboration when they were narrow specialists in different domains suggests that common ground building is less likely to occur in an electronic advice network. Because discussion participants, unlike members of a cross-functional workgroup, are not bound by task / outcome interdependence and shared goals, they will not bother engaging in collective elaboration when sharing their knowledge, if they do not understand others' previous inputs.

This dissertation thus advances our understanding of the relationship among expertise diversity, common ground, and collective elaboration in the context of an electronic advice network. It is collective elaboration that helps the advice seeker to leverage the differentiated knowledge held by discussion participants, but it is their pre-established common knowledge of syntactics and semantics that enables the discussion participants to engage in collective elaboration. This dissertation demonstrates that individuals' participation in multiple virtual communities of practice emerges is one way of developing synaptic and semantic understanding of the respective expertise domains in an electronic advice network.

Implications for Research on Knowledge Sharing in Virtual Communities

This dissertation makes several contributions to the virtual communities research on knowledge sharing by moving the focus toward how to best leverage diverse expertise *once* it is available in an electronic advice network. Much of the research on knowledge sharing in electronic advice network and the like has so far focused on how to make diverse expertise more available by studying why people share knowledge but little on how to best harness it. The findings of this dissertation suggest that the answer to the question of how to realize the potential of expertise diversity is more complicated than has been assumed; without understanding the communicative interactions in an electronic advice network, researchers will not have a clear picture of the relationship between expertise diversity and discussion outcomes. The inconsistency between the theoretical rationale supporting the positive effects of expertise diversity on the advice seeker's learning and performance and its weak empirical evidence has pointed to a significant gap in our academic understanding. Previous virtual communities studies have mainly limited their analyses to the individual-level characteristics of the knowledge sharer or the individual-message-level of knowledge sharing. These limitations have closed off opportunities to capture the complexity of the knowledge sharing process in discussion threads and thus leading to the lack of our understanding of the relationship between expertise diversity and discussion outcomes.

This dissertation thus makes a contribution to the literature by shedding light on the process by and the conditions under which expertise diversity promotes or fails to promote the advice seeker's (team) learning and performance. I investigated the relationship by considering how the difference, relevance, and novelty of domain-specific knowledge held by advice providers create both opportunities and challenges to the communication and understanding of discussion participants' knowledge. Specifically, this dissertation identified the moderating role of collective elaboration and cross-network common experience as a condition under which discussion participants could engage in collective elaboration.

This dissertation also advances our understanding of how the characteristics of an electronic advice network shape knowledge sharing in online discussion groups differently from knowledge sharing in traditional workgroups. The differences in the characteristics of an electronic advice network vs. a traditional workgroup explain why expertise diversity is less likely to trigger common ground building and collaborative knowledge integration in online discussion groups. This dissertation makes a contribution to the literature by developing virtual community context-specific constructs, collective elaboration and cross-network common experience.

Implications for Research on Common Ground

The findings of this dissertation hint boundary conditions for the findings of common ground building in groups. Team researchers have found that lack of shared syntactic and semantic understanding leads communicating parties to engage in a common ground building process through which each other's domain-specific knowledge gets translated and transformed to accrue mutual understanding. Interestingly, I found that online discussion group participants merely provided their inputs while not engaging in a dialogue when they lacked shared syntactic and semantic understanding of each other's domains. Unless having previously developed mutual syntactic and semantic understanding, discussion participants avoided exchanging their knowledge and perspectives *in conversation mode* – discussion was merely a compilation of ideas. These findings highlight that common ground building in discussion is less likely to occur when participants do not have shared goals and task and/or outcome interdependence that push them to negotiate the differences in their language, meaning, or position.

Implications for the Team Diversity Literature

While the moderating role of collective elaboration was theorized and empirically tested in the context of a particular group type – self-selected online discussion groups, the finding also provides implications for the research on team diversity. The mediating role of collective elaboration may offer an alternative explanation for why some prior team diversity research has reported inconsistent findings on the relationship between expertise diversity and team performance. Findings of no or negative relationship between diversity and group performance were interpreted as the consequence of dysfunctional information processing. Team researchers have typically attributed disruption in information processing to inter-group biases enacted by social categorization and contextual factors imposing groupthink or discouraging individuals to share what they uniquely know. Evidence from this dissertation alternatively suggests that one may find the absence of collective elaboration as a cause of dysfunctional information processing in groups. Even when members bring what they uniquely know to the discussion and are not trapped in the us vs. them mentality or in groupthink, the group may still not be capable of fully leveraging its potential, if the members are unable to engage in collective elaboration. They may not share enough understanding of each other's language, meaning, or perspective (Hypothesis 3) and/or are not motivated enough to engage in collective elaboration due to a lack of task or outcome interdependence that creates pressure to integrate each other's inputs.

Collective elaboration, as a new measurable construct, will help team diversity researchers to better explain where a disruption in the chain of group-level information processing occurs in some diverse teams. Previous studies have defined the intensive and collaborative group-level knowledge integration process assumed to help realize the performance potential of expertise diversity in diverse teams quite broadly. Several sequential sub-processes are confounded in the group process, making it difficult to understand which one is malfunctioning when there is a problem in the group-level information processing. The sub-processes include the exchange, discussion, and integration of ideas, knowledge, and perspectives that are relevant to a team's tasks (e.g., Van Knippenberg et al. 2004). This dissertation suggests that collective elaboration is an intermediate process that occurs during discussion – after the exchange process (i.e., sharing of knowledge uniquely held by individuals) and before the integration process (i.e., reconciliation and combination of task-relevant knowledge). If members are discouraged to share what they uniquely know, their knowledge exchange will be redundant and limited; if they lack common knowledge of the lexicon and meanings used in discussion, their discussion will impeded; or if they lack common practical and political interests and efforts to negotiate different approaches and perspectives to reach consensus, their integration process will be dysfunctional. By teasing out the sub-processes, team diversity researchers will be better able to understand where, in its group functioning, a diverse workgroup fails to realize its performance potential.

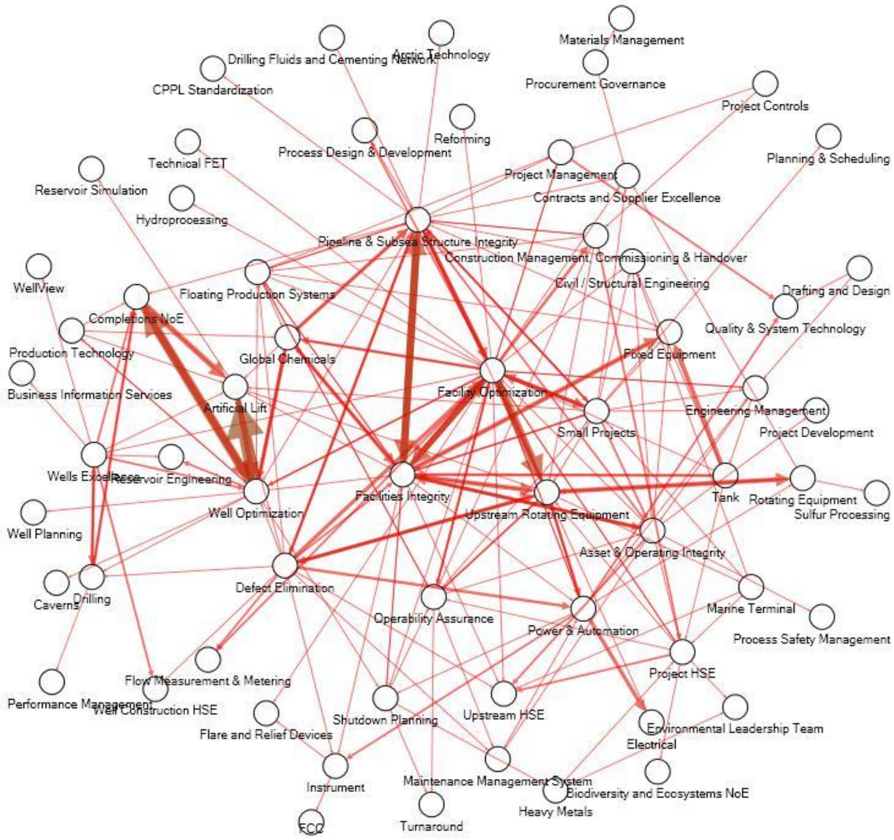
PRACTICAL IMPLICATIONS

The findings of this dissertation suggest some managerial implications for practitioners. While it is important to design incentives and tools to support personal motivation to share knowledge (so that more people will join an electronic advice network and more diverse expertise will become available), this dissertation suggests that managers should also focus on how to best leverage expertise diversity once it is available and accessible in an electronic advice network. Evidence shows that expertise diversity is a double edged sword. The advice seeker can benefit most or benefit least from diverse inputs. They key is how discussion participants communicate their advice when composing their messages. Discussion should be a “dialogue,” not just a compilation of individual ideas. Every participant should know how to become a good “elaborator.” Without collective elaboration, expertise diversity can be problematic in an electronic advice network. Therefore, managers should pay attention to how people from different communities share their knowledge in an electronic advice network in such a way that advice seekers can get the most out of the diverse inputs.

Given the important role of collective elaboration, managers are advised to create an online discussion protocol that guides how one might explicate one’s idea so that other discussion participants joining the discussion later, not to mention the advice seeker, can build on it more effectively. In addition to suggesting discussion protocols, it would be a good idea to promote the importance of collective elaboration and provide an incentive for those who provide excellent elaborated explanations. Also, advice seekers and/or discussion moderators should facilitate discussion participants’ collective elaboration by asking advice provides to clarify how their inputs are related to others’ inputs.

In addition, given the importance of broad cross-network common experience for collective elaboration, managers should think beyond how to increase employee participation in their “home” communities and think about supporting participation and knowledge sharing across different communities. Managers are advised to encourage and incentivize their employees to participate in their “home” communities of practice as well as in other virtual communities, so that they will develop good understanding of the languages, codes, and meanings used in other domains. A long term goal is to enhance common ground among different communities so that the collective intelligence of employees can be better harnessed to greater potentials through electronic advice networks.

Figure 12 A Snapshot of Cross-Community Knowledge Sharing Network



One way to identify which groups of communities would benefit most from investments in common ground would be to analyze previous discussion threads to find how many members of different communities frequently participate in the same discussion threads. The analysis will produce relationships of communities based on members' joint discussion participation. While some relationships among communities may seem obvious, given the relevance of their domains, some may be less obvious, pointing to opportunities to deliberately strengthen common ground by encouraging members of these communities to participate actively in one another's community.

Figure 12 depicts a snapshot of cross-community knowledge sharing network based on the 190 discussion threads I analyzed for this dissertation. The figure shows what community contributed knowledge to what community (based on whose members participated in whose discussion threads). A line weight indicates the frequency of knowledge contribution. From this analysis, I can identify that the Facility Optimization, Facility Integrity, and Upstream Rotating Equipment Communities are one of the most interwoven groups of communities when it comes cross-community knowledge sharing. Members of the three communities would be advised to participate in each other's community more often if they had not because the analysis suggests that there will be problems to be solved and decisions to be made that would particularly benefit from the collective intelligence of the members of the three communities. By encouraging members of the three communities to enrich their common experience across the communities, managers can expect them to be able to better interact and engage in collective elaboration and share knowledge more synergistically.

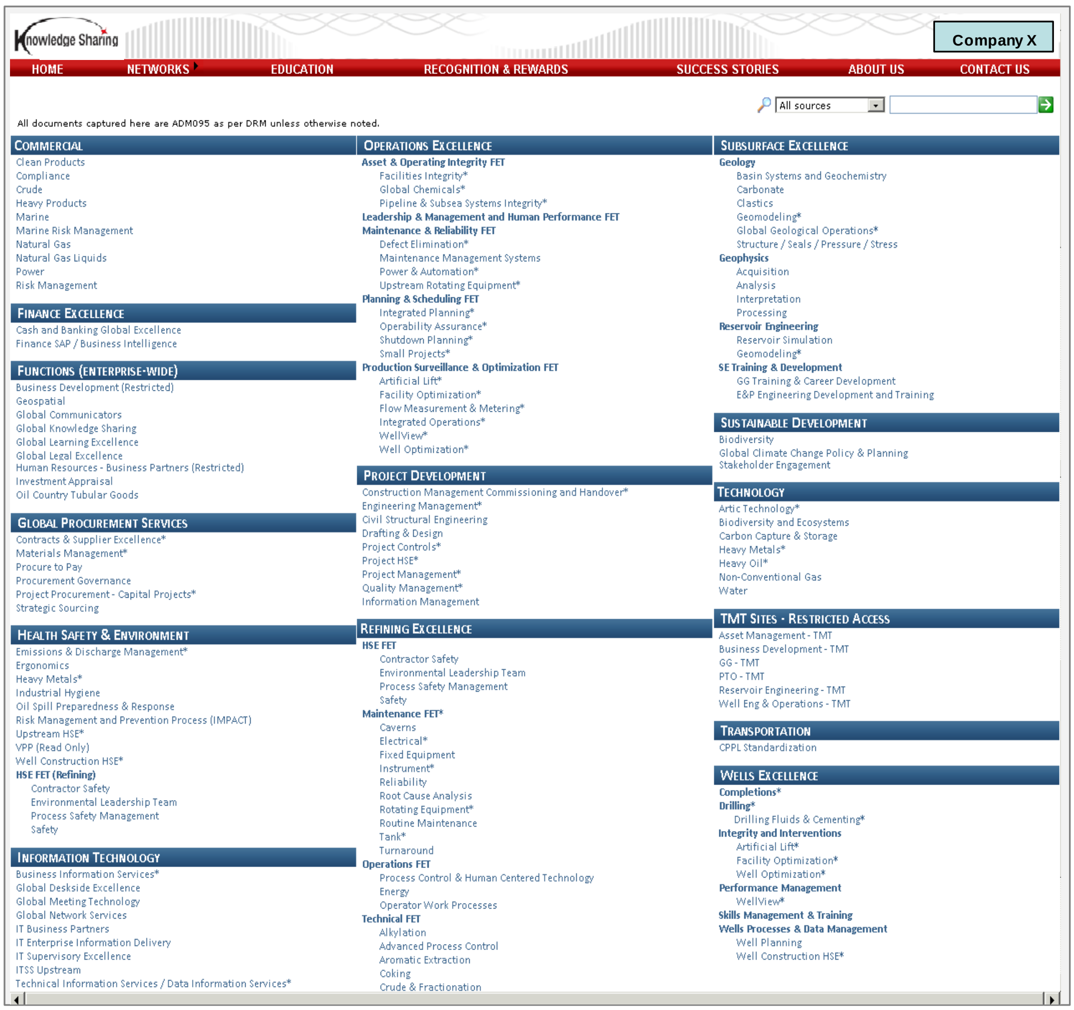
CONCLUSION

Taken together, the findings of this dissertation advance the research on knowledge sharing in an electronic advice network. This dissertation sheds light on the process by and the conditions under which expertise diversity promotes or fails to promote the advice seeker's (team) learning and performance. First, I introduce collective elaboration as a moderator of the relationship between expertise diversity and the advice seeker's (team) learning and performance outcomes in an electronic advice network. Where prior research has failed to find strong empirical evidence for the positive relationship between the two constructs, this dissertation shows that collective elaboration is the key to understanding why the relationship can be positive in some cases and negative in other cases. Furthermore, the collective elaboration construct can be also adopted by team diversity researchers to understand where, in its group functioning, a diverse workgroup may fail to realize its performance potential. Second, I further identify cross-network common experience as an important condition under which discussion participants are able to engage in collective elaboration. Evidence from this dissertation suggests that previously developed shared syntactic and semantic understanding, for instance, through regular participants in respective virtual communities, is critical for enabling elaborated exchange of knowledge and perspectives in an electronic advice network. Third, by articulating how the characteristics of an electronic advice network shape knowledge sharing in online discussion groups differently from knowledge sharing in traditional workgroups, this dissertation provides boundary conditions for the previous findings of the team literature on diversity and common ground.

APPENDIX I: Background of the Virtual Communities at the Research Site

Here provided is a snapshot of the list of virtual communities run at the field site as of January 2010.

Figure 13 List of Virtual Communities



Each community has clear business objectives and a focused area. Before communities are sanctioned, they must meet two requirements: a clear business case with support from leadership and a set of clearly defined deliverables in service to the business. Once a community is launched, knowledge management advisors from a centralized support team provide technical support and guidance through coaching to help sustain the community. For instance, community leaders were regularly informed of the “health status” of their community in terms of various activity measures (hits, uploads, membership, etc.) and advised on areas for improvement. Management has sent a strong signal to the employees that they take employees’ participation in virtual communities seriously. For instance, three communities have been recognized quarterly, based upon several criteria of collaboration and community performance, and four communities have been selected annually as Communities of the Year, which is considered a high honor within the company. This kind of attention and recognition has helped to grow the virtual communities over the years.

APPENDIX II: Data Collection and Analysis Timeline

Data Collection and Analysis Timeline	2010 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Note
Exploratory phase									
Getting familiar with the network portal									Permitted a remote access to the company's network portal (intranet)
- understanding how it is run and used									
- choosing networks and discussion threads for analysis									
- Analzying discussion threads to collect "Collective Elaboration" instances									
Collecting secondary data									Collaborated with the Knowledge Sharing Group to get the relevant secondary data
- Community membership, participants' HR, and discussion thread data									
Pre-survey interview									Two-week long interviews with 17 employees (15 interviews on site)
- to get to know the perceived value and challenges of using cross-network discussion threads									
- revising collectice elaboration coding instructions									
- useful for finalizing the research model (and the survey design)									
Survey data collection									
Finalizing the survey design and target group selection									Received feedback from the dissertation committee chair and the KS Group members
- Getting feedback and revising the survey draft									
- Finalizing the selection of the target group									
Pilot Survey Broadcasting and Adminstration									50 were preselected and invited to the pilot survey; 29 participated
- Getting feedback and revising the survey draft									
Full-scale Survey Broadcasting and Adminstration									227 were preselected and invited to the full-scale survey; after two reminders, 196 participated. Usable survey responses were 190.
- Advice seekers' evaluation of the replies provided in their discussion thread									
Analysis of survey and discussion threads/networks									
Analysis of discussion threads and networks									190 discussion threads were analyzed via SPSS-run hierachical regressions
- Analyzing online discussion interactions (content analysis)									
- Analyzing the characterstics of discussion participants and discussion threads									
Analysis of survey data									
- Analyzing survey results in relation to the archival data collected									
Post-analysis debriefing with the counterpart									Visited the field site to attend a workshop at which I met a few previous interviewees and KS Director to get their views on the results
- to get complementary insight from the KS Director for the preliminary findings drawn from the data analysis									

APPENDIX III: List of Interviewees

I interviewed the following practitioners prior to conducting a survey.

Table 10 List of Interviewees

Interviewee	Work Title	Home Community	Role	Discussion Participation	VC memberships	Interview Type
1	Pipeline & Subsea Structure Integrity Specialist	Small Project	Leader	Active advice seeker	8	Face-to-face
2	Senior Process Engineer	Facility Optimization	Leader	Active advice seeker/provider	10	Phone
3	Chemicals Advisor	Global Chemicals	Coordinator	Active advice provider	9	Phone
4	Supplier Quality Specialist	Contracts and Supplier Excellence	Core member	Active advice seeker/provider	15	Face-to-face
5	Pipeline Engineer	Pipeline & Subsea Structure Integrity	Core member		5	Face-to-face
6	Product Optimization Engineer Principal	Artificial Lift	Subject Expert	Active advice provider	9	Face-to-face
7	Asset And Operation Integrity Specialist	Asset & Operating Integrity	Leader	Active advice seeker/provider	14	Face-to-face
8	Rotating Equipment Engineer	Upstream Rotating Equipment	Leader	Active advice provider	7	Face-to-face
9	Inspection Advisor	Facilities Integrity	Core member	Active advice provider	7	Face-to-face
10	LNG Licensing Process Engineering Supervisor	Facility Optimization	Member	Active advice provider	7	Face-to-face
11	Pipeline & Subsea Structure Integrity Specialist	Well Optimization	Leader		11	Face-to-face
12	Pipeline Engineer	Pipeline & Subsea Structure Integrity	Leader		13	Face-to-face
13	Facilities & Process Engineering Manager	Facility Optimization	Sponsor	Active advice provider	10	Face-to-face
14	Process Engineer	Facility Optimization	(Former) Leader	Active advice provider	8	Face-to-face
15	Production Engineer	Facility Optimization	Leader	Active advice provider	13	Face-to-face
16	Integrity Engineer Lead	Pipeline & Subsea Structure Integrity	Core member	Active advice provider	2	Face-to-face
17	Planning Specialist	Shutdown Planning	Leader	Active advice provider	10	Face-to-face

Note: VC Memberships refer to the number of virtual communities of which the interviewee is a member.

APPENDIX IV: Survey Instruction Email

I sent the following invitation/instruction email to the target survey group, followed up by two more reminders. The email conveyed individual and discussion thread-specific information so that it looked personal to the survey invitees.

Dear ${m://FirstName},

Following up on Dan's email sent to you earlier ("Continuous Business Improvement Initiative - Action Required"), I'd like to give you instructions on our short survey with exclusive invitation.

The survey is designed to ask you specific questions about the threaded discussion on your recent post "${e://Field/Subject}" you posted on ${e://Field/NoE} Network on ${e://Field/PostedAt}.

In your post, you asked "${e://Field/Query}..."

In this survey, you will be asked to rate your recent advice seeking experience in relation to the threaded discussion on your post on several dimensions. The estimated completion time of this survey is 5 minutes.

Please be ensured that you will be assigned a code number. With this number, your responses will be known only to the academic researcher, me (Yong Kim), and not personally identifiable to the rest. The survey results will be reported in an aggregate manner. The aim of this survey is to discover general discussion patterns and practices that would lead to successful advice seeking outcomes, NOT to recognize or judge individuals or groups by their contribution by any means.

Your participation in this survey is voluntary, but we hope you can make yourself available for this 5-minute survey to help our ongoing effort to improve knowledge sharing at CompanyX. If you are willing to participate,

1) Please review the threaded discussion on your post before

beginning this survey by clicking on the following URL (or copy and paste it into your Internet browser):

${e://Field/Link}

2) Once you are done with your review, follow this link to the survey:
${l://SurveyLink?d=Take the Survey}

Or copy and paste the URL below into your internet browser:
${l://SurveyURL}

If you have a trouble opening the links or any question, or do not want to receive any more reminders of this survey, please email me at Kim.Yongsuk@contractor.CompanyX.com

This study has been reviewed and approved by CompanyX and The University of Texas at Austin Institutional Review Board (IRB). If you have questions about your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact - anonymously, if you wish - IRB by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu (IRB Approval Number: 2010-02-0098).

Your participation is greatly appreciated!

Best,

Yong Kim

PhD Candidate, Information Systems
McCombs School of Business
University of Texas at Austin

APPENDIX V: Survey Questionnaire

Default Question Block

Note. Thank you for choosing to provide your feedback on your recent advice seeking experience.

1. This survey consists of 10 questions. Some questions are long, but some are short and simple to answer. It will take about 5-6 minutes to finish them all.

2. Please note that the survey questions reflect our assumption that you posted your question while working on a task as part of a team or project.

3. Your responses will be aggregated with others' responses. There is no risk of having your personal assessment of the discussion on your post disclosed in association with your identity, so no worries!

Thanks again for your participation. We really appreciate it.

Check. Did you review the discussion on your post "${e://Field/Subject}" posted on ${e://Field/NoE} Network on ${e://Field/PostedAt} by following the link provided in the invitation email sent to you?

- Yes
- No

Notice. **Please review the discussion on your post before answering the survey questions by clicking on the URL below (or copy and paste it into your Internet browser):**

${e://Field/Link}

Note. **Please answer the following 10 questions in relation to your advice seeking experience regarding the particular discussion on your post "${e://Field/Subject}" you just reviewed (except for Q9).**

Q1. Is your team still working on the topic of your post (what you asked about)?

- Yes, we are currently working on it (case still open)
- No, we decided what to do (case closed)

Q2. To what extent did the discussion on your post enable your team to do the followings (with respect to the topic of your post)?

	No extent	Small extent	Some extent	Large extent	Great extent
Question your team's initial assumptions about the topic.	○	○	○	○	○

Challenge your team's perspective on the topic.	◌	◌	◌	◌	◌
Broaden your team's outlook about the topic.	◌	◌	◌	◌	◌
Rethink about the topic in a new or different way.	◌	◌	◌	◌	◌
Expand your team's scope of thinking about the topic.	◌	◌	◌	◌	◌
Improve your team's insight into the topic.	◌	◌	◌	◌	◌

Q3. To what extent did your team find the discussion on your post to be... ?

	No extent	Small extent	Some extent	Large extent	Great extent
Practical	◌	◌	◌	◌	◌
Valuable	◌	◌	◌	◌	◌
Informative	◌	◌	◌	◌	◌
Relevant	◌	◌	◌	◌	◌
Applicable	◌	◌	◌	◌	◌

Q4. To what extent did your team find the responses to your post to be... ?

	No extent	Small extent	Some extent	Large extent	Great extent
Compatible (with one another)	◌	◌	◌	◌	◌
Accurate	◌	◌	◌	◌	◌
Complete (collectively)	◌	◌	◌	◌	◌

Q5. To what extent did the discussion on your post help your team to... ?

	No extent	Small extent	Some extent	Large extent	Great extent
Do a good job of meeting your unit's needs	◌	◌	◌	◌	◌
Avoid making mistakes that would harm the business	◌	◌	◌	◌	◌
Make a decision based on the best available information	◌	◌	◌	◌	◌
Manage time effectively	◌	◌	◌	◌	◌
Meet important deadlines on time	◌	◌	◌	◌	◌
Create business value for your unit (such as issue resolution, LPO reduction, cost savings, risk reduction of HSE events, etc.)	◌	◌	◌	◌	◌
Achieve the objectives of your post	◌	◌	◌	◌	◌

Q6. Do you think your post concerns a topic that could be of interest and relevance to the members of multiple networks, rather than of just one network?

- Yes
- No

Q7. To what extent did the discussion participants exhibit the followings?

The discussion participants ...

	No extent	Small extent	Some extent	Large extent	Great extent
Had an interactive conversation					
Integrated what other participants had commented on					
Built upon other participants' responses (by clarifying, improving, questioning them, etc.)					
Elaborated their advice in relation to what other participants had commented on					

Q8. To what extent do you agree with the following statements?

"Prior to" seeking advice from the discussion forum "Ask & Discuss," our team had...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Full understanding of the topic of my post.					
Confidence to perform successfully all the activities related to the topic of my post.					
Adequate expertise to feel comfortable with the topic of my post.					

Q9. Overall, how satisfied are you personally with "Ask & Discuss" as a platform to seek and gain advice?

Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied

Q10. Did you or your team member(s) communicate with any of the discussion participants to get more information about his or her reply to your post outside the discussion thread (thus not captured in the current tread)?

- Yes
- No

Q10a. You reported "Yes." How many discussion participants did you contact offline for further advice seeking?

- 1
- 2-3
- 4-5
- 6 or above

Q10b. What communication channel(s) did you use? (Click all that apply)

- Face-to-face meeting
- Phone (or conference call)
- Instant messaging
- Email
- OneWiki
- Other

Q10c. What was the purpose of the offline advice seeking?

Final. If there is anything else you'd like to comment on your advice seeking experience or on "Ask & Discuss" in general, please use the following text box. For instance, if your team did not learn much from the discussion or found that the discussion did not contribute much to creating business impact, could you explain what was missing or insufficient? Or, any other types of comments are welcome.

THANK YOU SO MUCH FOR YOUR PARTICIPATION!

APPENDIX VI: Measures of Elaboration

<table>
<tr><th>Construct</th><th>Authors</th><th>Definition</th><th>Theoretical Basis</th><th>Group Type</th><th>Methods</th><th>Operationalization</th></tr>
<tr><td>Cognitive elaboration</td><td>Zhong and Majchrzak (2004)</td><td>The process whereby individuals who act autonomously explicate or stimulate others' explication and share with others so that each may understand initial differences in underlying assumptions and generate new knowledge to use in the new context</td><td>Webb and Palincsar (1996)</td><td>17 IS design project groups consisting of developers and clients</td><td>Group meeting note analysis</td><td>For each project, two meetings were observed and analyzed based on the following coding items:

• using observations, data, evidence, and background knowledge to support one's opinions and beliefs;
• using multiple representations to explain a concept;
• showing how to coordinate among different representations to solve problems;
• creating analogies to relate new ideas to familiar concepts;
• providing detailed descriptions of how to perform tasks;
• describing the relationship between different concepts;
• providing detailed justifications of the reasoning used to solve problems;
• comparing real-world experiences with information and explanations learned in meeting.</td></tr>
<tr><td>Collaborative elaboration</td><td>Majchrzak et al. (2005)</td><td>The communication technicques used by individuals to collaboratively stimulate others' self-elaboration in the group</td><td>Webb and Palincsar (1996)</td><td>7 software development project groups consisting of developers and clients</td><td>Multiple surveys</td><td>For each project, three meetings were observed and the meeting participants were surveyed with the following question:

In each meeting, to what extent did both clients and developers

(1) ask about the other party's unstated reactions to ideas,
(2) use multiple ways to describe an idea,
(3) identify differences that were not immediately obvious to participants
(4) focus on understanding or achieving others' personal goals, aside from program specifications,
(5) generate several alternatives that accomplished at least one shared goal, and
(6) compare alternatives to fallback positions?</td></tr>
<tr><td>Group information elaboration</td><td>Homan et al. (2007)</td><td>The exchange of information and perspectives, individual-level processing of the information and perspectives, feeding back the results of this individual-level processing into the group, and discussion and integration of their implications</td><td>van Knippenberg et al. (2004)</td><td>45 student groups randomly assigned to different experimental conditions</td><td>Lab experiment (decision making tasks)</td><td>Elaboration of information was measured by coding the videotapes of the 45 groups. Each group receieved 8 information items. For each information item, the following coding scheme was applied: (the higher the score, the more an information item was elaborated on)

<table><tr><th>score</th><th>Coding scheme</th></tr><tr><td>0</td><td>An info item was not mentioned at all during the discussion</td></tr><tr><td>1</td><td>Info was mentioned, but none of the other members reacted to it</td></tr><tr><td>2</td><td>one of the members mentioned an item of information and at least one of the other members reacted to it</td></tr><tr><td>3</td><td>a piece of information was mentioned by one of the group members, and one or more other members clearly responded by asking a question about it</td></tr><tr><td>4</td><td>the mentioning of an information item resulted in a conclusion about whether something was important or not</td></tr><tr><td>5</td><td>The information item was combined with another piece of information by one of the other group members</td></tr></table>
The total elaboration is determined by computing the sum of information elaboration for the eight information categories.</td></tr>
</table>

<table>
<tr><th>Construct</th><th>Authors</th><th>Definition</th><th>Theoretical Basis</th><th>Group Type</th><th>Methods</th><th>Operationalization</th></tr>
<tr><td>Group information elaboration</td><td>van Ginkel and van Knippenberg (2008)</td><td>The exchange of distributed information, careful consideration of this information and its implications, and discussion and integration of these implications</td><td>van Knippenberg et al. (2004)</td><td>91 student groups randomly assigned to different experimental conditions</td><td>Lab experiment (decision making tasks)</td><td>Group information elaboration was measured via audio-video analysis. Information elaboration was coded for each decisions issue based on the following coding scheme and a mean score over the three discussion issues was calculated.
<table>
<tr><th>Score</th><th>Coding scheme</th></tr>
<tr><td>1</td><td>when information was completely ignored by all four group members and the group immediately started with exchanging preferences</td></tr>
<tr><td>2</td><td>when one of the members did mention a crucial item of information, but none of the other members reacted to it</td></tr>
<tr><td>3</td><td>when one of the members mentioned an item of information and at least one of the other members reacted to it, but after this the group still failed to integrate it with the other information</td></tr>
<tr><td>4</td><td>when one crucial piece of information was mentioned by at least one of the group members, with at least two of the other three members clearly reacting to the mentioning of the information</td></tr>
<tr><td>5</td><td>when one crucial piece of information got fully discussed by at least three of the group members and integrated with other information and at least one other piece of information was clearly discussed by at least two of the four group members, however, without their discussion influencing the use of that item of information by the group as a whole</td></tr>
<tr><td>6</td><td>When at least two pieces of crucial information were fully discussed by at least three of the group members and integrated with other information</td></tr>
<tr><td>7</td><td>when all three crucial items of information were clearly and fully discussed by at least three of the four members, with them clearly having drawn conclusions with regard to what the best decision option would be in light of this information</td></tr>
</table></td></tr>
<tr><td>Group information elaboration</td><td>Homan et al. (2008)</td><td>The exchange of information and perspectives, individual-level processing of the information and perspectives, feeding back the results of this individual-level processing into the group, and discussion and integration of their implications</td><td>van Knippenberg et al. (2004)</td><td>58 student groups randomly assigned to different experimental conditions</td><td>Lab experiment and survey</td><td>After the experiment, information elaboration was assssed, via a three item self-report measure shown below, and was aggregated to the group level using the mean.

• The group members contributed a lot of information during the group task
• The group members contributed unique information during the group task
• During the task, we tried to use all available information</td></tr>
<tr><td>Elaboration of task-relevant information</td><td>Kearney et al. (2009)</td><td>The exchange, discussion, and integration of ideas, knowledge, and perspectives that are relevant to a team's tasks</td><td>van Knippenberg et al. (2004)</td><td>83 teams from 8 organizations</td><td>Survey</td><td>The following four survey items were developed:

• The members of this team complement each other by openly sharing their knowledge
• The members of this team carefully consider all perspectives in an effort to generate optimal solutions
• The members of this team carefully consider the unique information provided by each individual team member
• As a team, we generate ideas and solutions that are much better than those we could develop as individuals</td></tr>
</table>

APPENDIX VII: Collective Elaboration Coding Samples

Discussion Topic: Isolation valves under Thief Hatches

Discussion Thread	Coding item
Posted Tuesday, January 26, 2010 11:08 by Advice Seeker A Has anyone put an isolation valve in place under a thief hatch? We have a source service tank farm in which Operations would like to put butterfly valves under each of the thief hatches. This would allow them to isolate any one of the hatches for ease of replacement or repair of the unit. If this has been done, do you treat it as a carsealed valve under a PSV? Would it be necessary to have a person in place to watch the system while the hatch has been removed from service? Was there any issue with the additional valve weight on the top of the tank?	
Posted Wednesday, January 27, 2010 5:14 by Advice Provider B A, a couple of things to consider. I am not sure that a butterfly valve would be considered adequate isolation for the replace of a thief hatch. Depending on how sour your system is, there are likely man watch and safety issues involved with replace of the thief hatches that may make this more of a shut down issue. Not sure that you would get the correct design sigh off for this as I think that installation of valves prior to safety relief devices is a sign off from Josh Ho and Russ Lutin. Maybe talk to John Cooke about this.	Challenging the advice Clarifying one's advice
Posted Wednesday, January 27, 2010 8:28 by Advice Provider C Butterfly valves are not typically considered for positive isolation, even though there are zero leakage butterfly valves. Also the valve flapper might take up some area, which could affect the sizing of the valve. In addition, the flapper might obstruct the functioning (in open position, flapper protruding into thief hatch), especially if the thief hatch is having spring loaded pallet for vacuum protection. Definitely, this would be treated similar to carsealed valve under PSV. You need to include the isolation valve also under a PM program to ensure proper functioning of the valve.	Extending one's advice Conditioning one's advice
Posted Wednesday, January 27, 2010 10:04 by Advice Provider D I think the butterfly valve will definitely reduce your venting capacity. If this is one of the pressure/vacuum relief hatches you will want to car seal it open and have it on at least a monthly PM. Do you operators do car seal checks? For tank pressures, a butterfly valve might work OK with the proper seals. Doing the maintenance work under supplied air would be a good precaution.	Validating one's advice Conditioning one's advice Extending other's advice
Posted Wednesday, January 27, 2010 18:38 by Advice Provider E Is a butterfly valve considered a full port valve? For positive isolation, a gate valve or a knife gate might be better.	Conditioning other's advice
Posted Wednesday, January 27, 2010 21:15 by Advice Provider F Consider a gate valve for isolation purpose. The additional weight requires	Extending other's advice

support. Consider adding a spool and bleeder between the valve and hatch valve.	
Posted Thursday, January 28, 2009 6:24 by Advice Provider G The thief hatch also has an API bolt pattern and probably won't match up to the butterfly.	Extending other's advice

Discussion Topic: Offshore Riser Repair?

Discussion Thread	Coding item
Posted Tuesday, April 27, 2010 00:52 by Advice Seeker A Dear all, we almost completed our visual rigid riser inspection in our BU and we have found some findings during inspection which mostly are external corrosion and coating crack. In terms of mechanical integrity, the findings are still acceptable (no need to have reinforcement) but we need to stop the corrosion growth to prevent its getting worse. Any suggestion (best practice) to repair these riser findings?	
Posted Wednesday, April 27, 2010 9:37 by Advice Provider B I have used Clockspring products in the splash zone of a pipeline riser with good results. Check them at www.clockspring.com	
Posted Wednesday, April 27, 2010 9:42 by Advice Provider C In order to reply to your question we need additional information. What is the current coating, how close is it to the water line, is it in the splash zone? What is the in service surface temperature of the pipe?	Asking for clarification
Posted Wednesday, April 27, 2010 19:52 by Advice Seeker A *View Attachment* @B, Thanks for your info, we have Clockspring as an option but I guess, in our findings on the riser, it's too early to use it. Do you have other product which have you been applied? @C, Please find the additional information below- Current coating: …. **[OMITTED FOR CONFIDENTIALITY]**	Clarifying one's advice (question)
Posted Wednesday, April 28, 2010 0:34 by Advice Provider D It is most important to make sure you do not allow pockets, cracks, crevices, etc to persist in which water can puddle. You run the risk of creating chlorine ions which are very corrosive. Once chlorine is present, your corrosion rate will likely increase dramatically. I would even go so far as to say that this is even more important than what type of protection system or coating what you apply.	Clarifying one's advice
Posted Wednesday, April 28, 2010 10:57 by Advice Provider E You might consider Retrowrap HD from Corrosion Control International www.corrosioncontrol.com. They have several products, but the Retrowrap HD is designed for risers and has an operating temperature range of -20C to 100C. It does not provide structural reinforcement, but it sounds like you don't need reinforcement in this case. It is supposed to be easier to install than other	Clarifying one's advice

competing systems.	
Posted Thursday, April 29, 2010 21:42 by Advice Seeker A @D: Is it related to the surface preparation and application procedure? @E: thanks for information, we have used the typical application for previous repair, but I think for a small area, it would not be efficient. Do you have other wrapping products or maybe rust stopper paint that you have tried on your previous repair?	Asking for clarification
Posted Tuesday, May 11, 2010 9:55 by Advice Provider F *View Attachment* We've just completed a small repair on a 10" gas import riser on the L platform K using Z. I've attached the procedure and some photos.	
Posted Wednesday, May 12, 2010 8:41 by Advice Provider G F: did you do any qualification testing to prove this method? If so, would you post both the testing requirements and results? Thanks	Asking for clarification
Posted Friday, May 14, 2010 5:39 by Advice Provider F G, pre qualification was not asked for. The application was to the upper surface of the Neoprene only and due to physical accessibility (rope access) the need for a rapid turn round was needed to limit the time spent in this location. The system has been used successfully to more demanding repairs in similar situations on non Company X facilities so a track record can be demonstrated. Sorry, I don't have further records but contact with the manufacture might provide info.	Clarifying one's advice
Posted Wednesday, May 19, 2010 21:19 by Advice Seeker A *View Attachment* @F, thanks for sharing your experience with Z. @All, I have made some simple tabulation of the type of possible repair product refer to their datasheet specification. It might be useful.	

APPENDIX VIII: PLS Analysis and Results

As a complimentary test, I ran PLS to check the robustness of the results from the sequential regression analysis. I first present the measurement model to confirm the convergent and discriment validities of the multi-item constructs, followed by the structural model to test the hypotheses.

MEASUREMENT MODEL: CONVERGENT AND DISCRIMINANT VALIDITY

Corroborating the results of the validity tests presented in the previous data analysis section, both convergent and discriminant validities of the constructs were confirmed as shown in Tables 11 - 13. All of the composite reliability coefficients and Cronbach's alphas are above .70 and each AVE is greater than .50 (Table 11), indicating that the measurements are reliable and each latent construct can account for at least 50 percent of the variance in the indicators (Chin 1998). The t-values indicate that the indicators are significant below the .001 level. Discriminant validity is demonstrated in Table 13, of which results show that the square root of the AVE is greater than all of the inter-construct correlations. The cross-loadings table (Table 12) further supports adequate convergent and discriminant validity.

Table 11 Loadings of the Indicator Variables

Construct	Indicator	Composite Reliability	AVE	Cronbach's alpha	Loading	T-value
Learning	Learning1	0.93	0.72	0.90	.858	16.71
	Learning2				.887	18.31
	Learning3				.796	13.73
	Learning4				.869	17.77
	Learning6				.839	14.46
Performance	Performance1	0.92	0.70	0.89	.711	11.25
	Performance2				.840	17.62
	Performance3				.915	17.91
	Performance4				.873	16.55
	Performance5				.841	14.39
Knowledge Level	KnwLv1	0.94	0.83	0.90	.909	19.05
	KnwLv2				.902	17.52
	KnwLv3				.919	21.54

Table 12 Cross-loadings

Indicators	Knowledge_level	Learning	Performance
KnwLv1	**.909**	-.443	-.215
KnwLv2	**.902**	-.372	-.176
KnwLv3	**.919**	-.429	-.213
Learning1	-.398	**.858**	.613
Learning2	-.435	**.887**	.550
Learning3	-.360	**.796**	.504
Learning4	-.366	**.869**	.565
Learning6	.386	**.839**	.609
Performance1	-.110	.461	**.711**
Performance2	-.221	.615	**.840**
Performance3	-.250	.616	**.915**
Performance4	-.163	.531	**.873**
Performance5	-.170	.567	**.841**

Table 13 Correlations

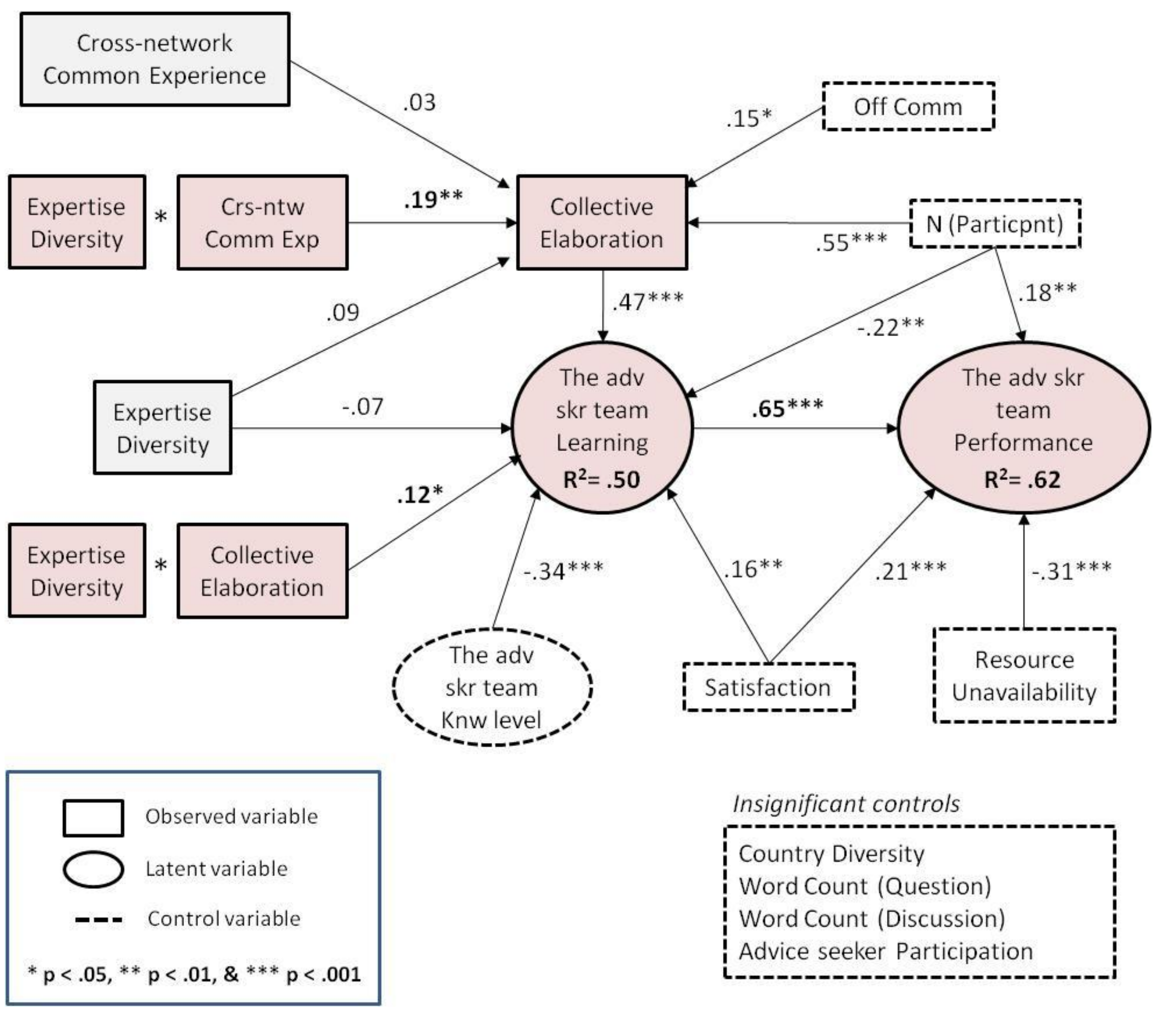
	AdvSkr_participation	CE	CntryDiv	Cross-network_Comm_Exp	ExpDiv	Knowledge_level	Learning	NParticipant	Offline_Cmm	Performance	Resource_constraints	Satisfaction	WordCnt_AdvSkr_Q	WordCnt_Discussion
AdvSkr_participation	N/A													
CE	0.08	N/A												
CntryDiv	-0.01	0.18	N/A											
Cross-network_Comm_Exp	-0.03	-0.06	-0.04	N/A										
ExpDiv	-0.01	0.10	-0.02	0.50	N/A									
Knowledge_level	-0.13	-0.17	-0.06	-0.09	-0.04	**0.91**								
Learning	0.18	0.52	0.09	0.00	-0.04	-0.46	**0.85**							
NParticipant	0.14	0.56	0.33	-0.20	0.09	-0.05	0.17	N/A						
Offline_Cmm	0.20	0.19	0.02	0.00	0.02	-0.12	0.25	0.11	N/A					
Performance	0.10	0.66	0.11	0.04	0.04	-0.22	0.67	0.25	0.18	**0.84**				
Resource_constraints	0.00	-0.11	-0.05	0.01	-0.17	-0.02	0.16	-0.04	0.00	-0.22	N/A			
Satisfaction	0.03	0.32	0.00	-0.08	0.01	-0.06	0.33	0.14	0.08	0.43	0.00	N/A		
WordCnt_AdvSkr_Q	0.22	0.10	-0.03	-0.15	-0.11	0.05	0.10	0.21	0.08	0.10	-0.06	0.02	N/A	
WordCnt_Discussion	0.36	0.36	0.21	-0.09	0.03	-0.15	0.23	0.68	0.16	0.17	0.02	0.12	0.34	N/A

Notes. Boldface numbers on diagonal are the square root of AVE. Off-diagonal numbers refer to correlations among constructs. For single-item constructs, only correlations are presented. For discriminant validity, diagonal elements should be larger than off-diagonal elements.

STRUCTURAL MODEL: HYPOTHESIS TESTING

Figures 14 and 15 illustrate the results of PLS analysis, Table 14 presents the path coefficients of all the paths shown in the model, and Table 15 contains the outermodel loadings of the multi-item constructs (latent variables).

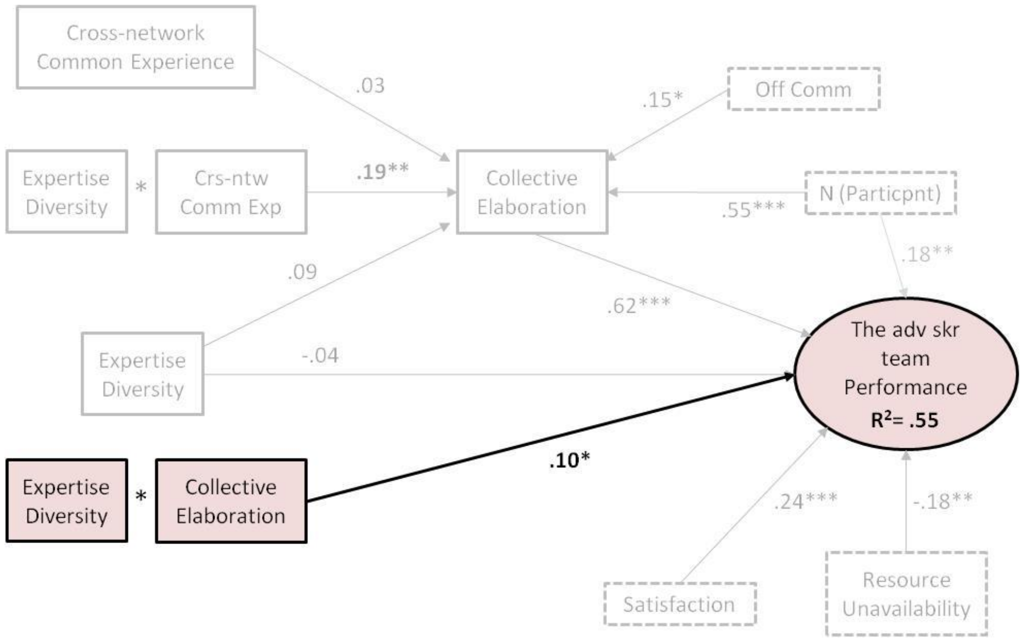
Figure 14 PLS Results



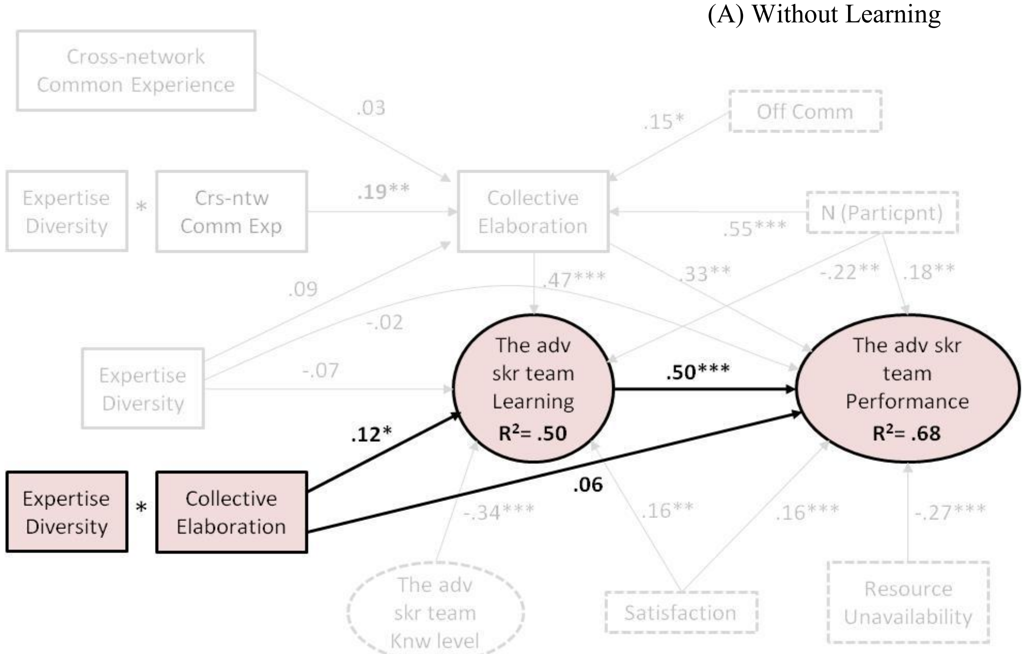
In Figure 14, the R^2 values of .50 and .60 both indicate that a significant amount of variance of the advice seeker team's learning (and performance) is explained by the model. In comparison to the results of the regression analysis, there was one more control variable that turned out be significant. The number of discussion participants was found to be significantly related to the advice seeker's team learning negatively ($b = -.22$, $t=2.35$, $p<.05$) and to the advice seeker's team performance ($b=.18$, $t=2.69$, $p<.05$) and collective elaboration ($b=.55$, $t=10.82$, $p<.001$) positively. While the positive relationship between collective elaboration and the number of participants makes sense, the other relationships between collective elaboration and learning and performance seem puzzling. In particular, while more investigation is needed to interpret the finding of negativity, this finding further suggests that an increase in the size of discussion participants does not necessarily improve the advice seeker's (team) learning and may even impede learning under some conditions.

Hypothesis 1 states that expertise diversity and collective elaboration interacts to affect the advice seeker team learning. The results of PLS analysis show that the Expertise Diversity * Collective Elaboration—Learning link is significant ($b = .12$, $t=2.28$, $p<.05$), supporting Hypothesis 1.

Figure 15 Mediation Test of Learning



(A) Without Learning



(B) With Learning

Hypothesis 2 states that the advice seeker team learning mediates the interactive effect of expertise diversity and collective elaboration (Expertise Diversity * Collective Elaboration) on the advice seeker's team performance. Based on the mediation procedure of Barron and Kenny (1986), Liang and colleagues (2007) tested a series of mediation using PLS. Accordingly, I followed their approach. First, as shown in Figure 14, the Expertise Diversity * Collective Elaboration—Learning link and the Learning—Performance link are both significant ($b = .12$, $t=2.28$, $p<.05$; $b=.65$, $t=11.98$; $p<.001$, respectively). Second, I compared the significant interaction effect of expertise diversity and collective elaboration on performance when learning was omitted from the model with the interaction effect when learning was added to the model.

As shown in Figure 15, the addition of learning as a control variable diminished the interactive effect of expertise diversity and collective elaboration on performance. The interactive effect, which was highly significant with no learning ($b = .10$, $t=2.45$, $p<0.05$; Fig.15(A)), became insignificant with the addition of learning ($b = .06$, $t=1.99$, n.s.; Fig.15(B)). Thus, Hypothesis 2 is supported.

Finally, Hypothesis 3 states that expertise diversity and discussion participants' cross-network common experience interacts to affect collective elaboration. The results of PLS analysis show that the Expertise Diversity * Cross-Network Common Experience—Collective Elaboration link is significant ($b = .19$, $t=3.06$, $p<.01$; Fig. 14), supporting Hypothesis 3.

In summary, both analyses, sequential regression and PLS, produce nearly the same results, further confirming the robustness of the findings.

Table 14 Path Coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
AdvSkr_participation -> Learning	0.06	0.06	0.06	0.06	1.06
AdvSkr_participation -> Performance	0.00	0.00	0.05	0.05	0.00
CE -> Learning	0.47	0.47	0.06	0.06	7.75
CntryDiv -> Learning	0.03	0.03	0.06	0.06	0.53
CntryDiv -> Performance	0.00	0.00	0.05	0.05	0.16
Cross-network_Comm_Exp -> CE	0.03	0.02	0.07	0.07	0.35
ExpDiv -> CE	0.09	0.09	0.07	0.07	1.28
ExpDiv -> Learning	-0.07	-0.07	0.06	0.06	1.17
ExpDiv * CE -> Learning	0.12	0.13	0.05	0.05	2.28
ExpDiv * Cross-network_Comm_Exp -> CE	0.19	0.19	0.06	0.06	3.06
Knowledge_level -> Learning	-0.34	-0.35	0.06	0.06	6.34
Learning -> Performance	0.65	0.64	0.05	0.05	11.98
NParticipant -> CE	0.55	0.55	0.05	0.05	10.82
NParticipant -> Learning	-0.22	-0.22	0.09	0.09	2.35
NParticipant -> Performance	0.18	0.19	0.07	0.07	2.69
Offline_Cmm -> CE	0.15	0.15	0.06	0.06	2.53
Offline_Cmm -> Learning	0.10	0.11	0.06	0.06	1.86
Offline_Cmm -> Performance	-0.00	-0.00	0.05	0.05	0.12
Resource_constraints -> Performance	-0.31	-0.31	0.05	0.05	6.64
Satisfaction -> Learning	0.16	0.16	0.06	0.06	2.66
Satisfaction -> Performance	0.21	0.21	0.05	0.05	3.96
WordCnt_AdvSkr_Q -> Learning	0.06	0.06	0.06	0.06	0.97
WordCnt_AdvSkr_Q -> Learning	0.03	0.03	0.04	0.04	0.71
WordCnt_Discussion -> Learning	0.08	0.08	0.09	0.09	0.89
WordCnt_Discussion -> Performance	-0.13	-0.13	0.07	0.07	1.95

Table 15 Outer Model Loadings

Original Sample (O)	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
KnwLv1 <- Knowledge_level	0.91	0.90	0.05	0.05	19.05
KnwLv2 <- Knowledge_level	0.85	0.85	0.05	0.05	17.52
KnwLv3 <- Knowledge_level	0.84	0.84	0.04	0.04	21.54
Learning1 <- Learning	0.88	0.87	0.05	0.05	16.71
Learning2 <- Learning	0.95	0.95	0.05	0.05	18.31
Learning3 <- Learning	0.79	0.79	0.06	0.06	13.73
Learning4 <- Learning	0.95	0.95	0.05	0.05	17.77
Learning6 <- Learning	0.87	0.87	0.06	0.06	14.46
Performance1 <- Performance	0.81	0.80	0.07	0.07	11.25
Performance2 <- Performance	1.00	1.00	0.06	0.06	17.62
Performance3 <- Performance	0.98	0.97	0.05	0.05	17.91
Performance4 <- Performance	0.94	0.94	0.06	0.06	16.55
Performance5 <- Performance	0.88	0.87	0.06	0.06	14.39

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